VIII. *Account of a series of observations, made in the summer of the year* 1825, *for the purpose of determining the difference of meridians of the Royal Observatories of Greenwich and Paris; drawn up by* J. F. W. Herschel, *Esq. M. A. Sec. R. S. Communicated by the Board of Longitude.*

Read January 12, 1826.

Operations having been carried on to a considerable extent in France, and other countries on the continent, for the purpose of ascertaining differences of longitude by means of signals, simultaneously observed at different points along a chain of stations; and the Royal Observatory at Paris, in particular, having been connected in this manner with a number of the most important stations, it was considered desirable by the French government that the Royal Observatory at Greenwich should be included in the general design. The British Board of Longitude was accordingly invited to lend its co-operation towards carrying into effect a plan for that purpose; and the invitation being readily accepted on their part, I was deputed, in conjunction with Capt. Sabine, in the course of the last summer, to direct the practical details of the operation on the British side of the channel, and to make the necessary observations. Every facility was afforded us in making our dispositions, on the part of the different branches of His Majesty's government to which it was found necessary to apply. A detachment of artillery was placed, by his Grace the Duke of Wellington, Master

General of the Ordnance, under the orders of Capt. SABINE. Horses, waggons, and men, were furnished for the conveyance of a tent, telescopes, rockets, and other apparatus; and four of the chronometers belonging to the Board of Admiralty were placed at our disposal. The rockets required for making the signals were furnished us from France. It would have been easy, doubtless, to have procured them from the Royal Arsenal at Woolwich; but on the representation of Colonel BONNE, to whom the principal direction of the operations in France was intrusted, it was thought more advisable to accept an offer made to us of any number which might be required, prepared at Paris expressly for similar operations, carrying a charge of 8 ounces of powder, the instantaneous explosion of which, at their greatest altitude, was to constitute the signals to be observed.

Our previous arrangements being made, on the 7th of July I left London; and after visiting the station pitched upon at Wrotham, which was the same with that selected by Capt. KATER and Major COLBY, as a principal point in their triangulation in 1822; and finding it possessed of every requisite qualification for the purpose of making the signals, from its commanding situation, being unquestionably the highest ground between Greenwich and the coast, proceeded to Fairlight Down, near Hastings, where I caused the very convenient observatory tent, belonging to the Board of Longitude, to be pitched immediately over the centre of the station of 1821, which was readily found from the effectual methods adopted by the gentlemen who conducted the trigonometrical operations in that year, for securing this valuable point. Here, on the 8th, I was joined by Capt.

SABINE, who, it had been arranged, should proceed to the first observing station on the French side of the Channel, there to observe, in conjunction with Colonel BONNE, the signals made on the French coast, and those made at the station of Mont Javoult; which latter were to be observed immediately from the observatory at Paris; while, on the other hand, it was agreed that M. le Lieutenant LARGETEAU, of the French corps of geographical engineers, should attend at Fairlight, on the part of the French commission, and observe, conjointly with myself, the signals made at La Canche, the post on the opposite coast (elevated about 600 feet above the sea, being nearly the level of Fairlight Down) and also those to be fired from Wrotham Hill, which were expected to be immediately visible from a scaffold, raised for the purpose on the roof of the Royal Observatory of Greenwich. By this arrangement, and by immediate subsequent communication of the observations made at each station, it was considered that the advantage of two independent lines of connexion, a British and a French, would be secured between the two extreme stations; i. e. the two national observatories; every possibility of future misunderstanding obviated, and all inconvenience on either side, arising from delay, or miscarriage in the transmission of observations, be avoided.

With the assistance of Capt. SABINE, and by the help of exact information as to the azimuths of Wrotham and other nearer stations in the triangulation of 1821, with which Capt. KATER had obligingly furnished us, and of which Fairlight Church proved the most convenient, being close at hand and favorably situated, and easily visible in the twilight; and

from the previously calculated azimuth of La Canche (114° 30′ E.); four night glasses by DOLLOND, provided at the order of the Board of Longitude expressly for this operation, and which I had caused to be fixed on posts firmly driven into the ground beneath the tent, were then pointed, two on the station of La Canche, and two on that of Wrotham Hill. Those directed to the former were of four inches clear aperture, the others of three. In case of any difficulty arising as to the pointing, I had taken care to provide myself with an excellent eight-inch repeating theodolite, on the REICHENBACH construction, by SCHENCK, of Berne; but it was found unnecessary to use it, as the night glasses were purposely constructed with an azimuthal motion, and a rough graduation read off by an adjustable vernier, so as to allow their being set at once a few minutes before the observations commenced, by taking Fairlight steeple as a zero point; a circumstance which proved exceedingly convenient, as it allowed of their being dismounted after each night's observations, and removed to a place of security; and thus rendering it unnecessary to harass our small party by keeping guard in our absence.

On the night of the 8th I had directed blue lights to be fired at Wrotham, as a trial of the visibility of the stations, or rather as a verification of the pointing of the telescopes; for on the former point there could be no doubt, the station at Wrotham being situated precisely on the edge of the escarpment of the chalk which borders the Weald of Kent, and having been actually connected with Fairlight by direct observation, while no obstacle but a low copse wood, over which it might fairly be presumed that no rocket would

fail to rise, separated it from a direct view of Greenwich, at about 20 miles distance. Either from haze in the atmosphere, or from the too great distance, nothing was seen that night or the next; which however caused no uneasiness, as we could depend on our instruments and information. The next morning Capt. SABINE quitted Hastings, and joined Col. BONNE, at his post, on the morning of the 10th, the day appointed for the commencement of the observations; meanwhile I was joined by M. LARGETEAU, who remained with me the whole time of their continuance, performing every part of a most scrupulous and exact observer, as the observations herewith communicated will abundantly testify.

The observations were continued during 12 nights, 10 signals being made at each rocket station every night. The weather throughout the whole of this time was magnificent, and such as is not very likely to occur again for some years; a circumstance of the last importance in operations of this nature, where lights are to be seen across nearly 50 miles of sea, and also by reason of the verification of the sidereal times at the observatories by transits. One night only a local fog deprived us of the sight of 13 out of the 20 signals; but on the whole, out of 120 made at Wrotham, no less than 112 were seen from Fairlight (about 40 miles) and 89 from Greenwich; while out of the same number made at La Canche, 93 were observed at the former post. I am sorry to add, however, that owing to a combination of untoward circumstances, which no foresight or exertion on the part of Capt. SABINE or myself could possibly have led us to calculate on, or enabled us to prevent, and which the most zealous endeavours on that of Col. BONNE failed to remedy, no

less than eight out of the twelve nights' observations were totally lost, as to any result they might have afforded, and the remainder materially crippled; so that a much more moderate estimate of the value of our final result must be formed, than would otherwise have been justified. Still it is satisfactory to be able to add, (such is the excellence of the method) that a result on which considerable reliance can be placed, may be derived from the assemblage of the observations of these four nights; and when it is stated that this result appears not very likely to be a tenth of a second in error, and extremely unlikely to prove erroneous to twice that amount, it will perhaps be allowed that, under such circumstances, more could hardly be expected.

I. *Observations made at the Royal Observatory at Paris.*

Station de l'Observatoire Royal. Feux de Mont-Javoult.

Jours, Juillet 1825.	No. des Signaux.	Apparition des Signaux. Obsérves en tems de la Pendule.	Apparition des Signaux. En tems Sideral.	Noms des Observateurs.	Avance Pendule sur le tems Sideral.	Remarques.
		A*	B			
☾	7	18h 15′ 52″.0	18h 15′ 40″.3	Mathieu	- -	brillant élevé.
		52.2	40.5	Savary		
		52.0	40.3	Nicollet		
	8	26 17.5	26 5.8	Mathieu	- -	excessivement faible : observation douteuse.
18	9	35 52.9	35 41.2	Mathieu	11″.7	très brillant, assez élevé.
		53.1	41.4	Savary		
		52.5	40.8	Nicollet		
	10	45 56.0	45 44.3	Mathieu	- -	faible, peu élevé.
		55.9	44.2	Savary		
		55.6	53.9 †	Nicollet		† So in the original. (H.)
♂	1	17 19 49.8	17 19 37.0	Mathieu	- -	brillant.
		49.8	37.0	Savary		
	2	29 42.4	29 29.6	Mathieu	- -	faible, élevé.
	5	59 44.4	59 31.6	Mathieu	- -	assez brillant, peu élevé.
		44.6	31.8	Savary		
19	6	18 9 58.1	18 9 45.3	Mathieu	12.8	assez brillant, peu élevé.
		58,1	45.3	Savary		
	8	29 54.3	29 41.5	Mathieu	- -	peu brillant.
		54.4	41.6	Savary		
	9	40 5.5	39 52.7	Mathieu	- -	brillant, très élevé.
		5.1	52.3	Savary		
	10	49 56.3	49 43.5	Mathieu	- -	brillant, très élevé.
		56.1	43.3	Savary		
☿	2	17 33 50.7	17 33 36.5	Mathieu	- -	très faible, observation très douteuse.
	3	43 45.5	43 31.3	Mathieu	- -	brillant, assez élevé.
		45.5	31.3	Savary		
	4	53 49.8	53 35.6	Mathieu	- -	très faible, bas.
	5	18 3 46.7	18 3 32.5	Mathieu	- -	très brillant, très élevé.
		46.8	32.6	Savary		
20	6	13 48.6	13 34.4	Mathieu	14.2	assez brillant.
		48.1	33.9	Savary		
	7	23 49.9	23 35.7	Mathieu	- -	peu brillant, assez élevé.
		49.7	35.5	Savary		
	8	33 53.3	33 39.1	Mathieu	- -	peu brillant, assez élevé.
		53.6	39.4	Savary		
	9	43 56.3	43 42.1	Mathieu	- -	brillant, très élevé.
		56.4	42.2	Savary		
	10	53 54.2	53 40.0	Mathieu	- -	brillant, très élevé.
		54.6	40.4	Savary		

* La colonne (A) renferme les nombres qui ont été trouvés par les observations des feux. La colonne (B) renferme les nombres de la colonne (A) corrigés de l'avance de la pendule. Les nombres de la colonne (B) sont ceux qui doivent être comparé au tems sideral absolu de Greenwich.

Observations made at the Royal Observatory at Paris.

Station de l'Observatoire Royal. Feux de Mont-Javoult.

Jours, Juillet 1825.	No. des Signaux.	Apparition des Signaux.		Noms des Observateurs.	Avance Pendule sur le tems Sideral.	Remarques.
		Obsérves en tems de la Pendule.	En tems Sideral.			
		A	B			
♃	1	$17^h 27' 43.''2$	$17^h 27' 26.''8$	Mathieu	- -	peu brillant, peu élevé.
		43.5	27.1	Savary		
	2	37 39.5:	37 23.1:	Mathieu	- -	brillant, très élevé, j'ai vu une trainée lumineuse de 37″ à 40″ j'estime le grand éclat vers 39″.5.
	3	47 48.3	47 31.9	Mathieu	- -	assez brillant, très élevé.
		48.7	32.3	Savary		
	4	57 42.3	57 25.9	Mathieu	- -	faible, peu élevé.
		59.6	43.2	Savary	- -	autre feu brillant et très élevé.
	5	18 7 37.5	18 7 21.1	Savary	- -	très faible, bas.
21		7 57.3	7 40.9	Mathieu	16″.4	autre feu assez brillant et élevé.
		57.4	41.0	Savary		
	6	17 41.3	17 24.9	Savary	- -	faible et peu élevé.
		17 46.8	17 30.4	Mathieu	- -	autre feu assez brillant, élevé.
		46.6	30.2	Savary		
	7	27 46.5	27 30.1	Mathieu	- -	assez brilliant et élevé, explosion non instantanée.
		46.4	30.0	Savary		
	8	37 51.6	37 35.2	Savary	- -	faible et bas.
		37 57.2	37 40.8	Mathieu	- -	très brillant et très élevé.
		57.1	40.7	Savary		
	10	57 56.7	57 40.3	Savary	- -	premier feu, assez brillant, mais bas.
		58 0.3	57 43.9	Mathieu	- -	autre feu, très brillant, assez élevé.
♀	1	17 31 29.9	17 31 12.3	Mathieu	- -	très brillant, très élevé.
		29.6	12.0	Savary		
	2	41 29.3	41 11.7	Mathieu	- -	assez brillant, peu élevé.
		29.3	11.7	Savary		
	3	51 36.2	51 18.6	Mathieu	- -	assez brillant et élevé.
		36.4	18.8	Savary		
	4	18 1 33.3	18 1 15.7	Mathieu	- -	assez brillant et élevé.
22		33.2	15.6	Savary	17.6	
	5	11 39.4	11 21.8	Mathieu	- -	très brillant et assez élevé.
		39.2	21.6	Savary		
	6	22 1.3	21 43.7	Mathieu	- -	assez brillant et élevê.
		1.1	43.5	Savary		
	7	31 49.3	31 31.7	Mathieu	- -	assez brillant et assez élevé.
		49.5	31.9	Savary		
	9	51 47.5	51 29.9	Mathieu	- -	assez brillant et assez élevé.
		47.3	29.7	Savary		

On a observé les signaux de feu donnés à Mont-Javoult près de Gisors dans un petit cabinet situé dans la partie supérieure de l'observatoire. Les lunettes dont on se servait étaient très près d'une pendule que j'avais placée dans ce cabinet; ensorte que l'on pouvait aisement prendre la seconde et la compter par le moyen des battemens du balancier, qui s'éntendaient parfaitement. Après l'observation des signaux je comparais, à l'aide d'un chronomètre, la pendule à celle qui est en bas à côté de la lunette meridienne. Ces comparaisons m'ont donné pour chaque jour l'avance de la pendule des feux sur celle de la lunette méridienne et par suite sur le tems sideral. Je me suis attaché à régler la pendule, qui est près de la lunette méridienne par les passages durant le jour des sept étoiles suivantes : Aldebaran, La Chèvre, Rigel, α Orion, Arcturus, α Couronne, α Serpent. J'ai observé 5 de ces étoiles le 18, 3 le 19, 7 le 20, 4 le 21, et 5 le 22. J'ai calculé leurs positions apparentes d'après les *positions moyennes et les corrections in Right Ascension* données par Mr. South.

L. MATHIEU.

II. *Captain* SABINE'S *observations at Lignieres.*

Chronometer of Motel, No. 39.

Observations du 18 Juillet, huitième jour.

	Apparition des Signaux, en tems de la montre. à l'Orient. h. min. sec.	à l'Occident. h. min. sec.	Remarques.
1			
2			
3	9 49 33·4	9 54 52,	Signal de La Canche [faible.
4	9 59 34,0	non vu.	
5	10 09 37,2	10 14 54,du	Signal de La Canche [très faible.
6	10 19 33,6	non vu.	
7	10 29 34,4	id.	
8	non vu.	id.	
9	10 49 32·8	id.	
10	10 59 33·6	id.	

Le Colonel BONNE à Mont-Javoult, moi seul.
Les signaux de Mont-Javoult bien vus, excepté le 7me qui était faible.

Observations du 19 Juillet, le neuvième jour.

	Apparition des Signaux, en tems de la montre. à l'Orient. h. min. sec.	à l'Occident. h. min. sec.	Remarques.
1			
2	9 39 30·4	fa. du.	
3	- -	9 44 50	
4			
5	10 09 39,6	10 14 50,4	———
6			
7	- -	10 34 49,6	
8			
9	10 49 41,2	10 54 53,6	
10	10 59 30,0	11 05 01,4	

Observations du 20 Juillet, le dixième jour.

	Apparition des Signaux, en tems de la montre. à l'Orient. h. min. sec.	à l'Occident. h. min. sec.	Remarques.
1			
2			
3	9 49 39·6		
4			
5	10 09 27·6		———
6			
7	10 29 27·2		
8			
9	10 49 30·5	10 54 47·6	faible.
10			

Observations du 21 Juillet, le onzième jour.

	Apparition des Signaux, en tems de la montre. à l'Orient. h. min. sec.	à l'Occident. h. min. sec.	Remarques.
1	- -	9 34 50·8	
2	9 39 24·8		
3	9 49 32·8	9 54 50·4	
4	- -	10 04 53·2	Le 6me signal de Mont-Javoult rasant l'horizon.
5	10 09 38·4	10 14 51,2	
6	10 19 26·4	- -	
7	- -	10 34 49·6	
8	10 39 33·2	10 44 59·4	
9			
10	10 59 33·2	11 04 52,0	

Captain SABINE'S *observations of signals seen from Lignieres.*

Observations du 22 Juillet, 12me jour.			
	Apparition des Signaux, en tems de la montre. à l'Orient.	à l'Occident.	Remarques.
	h. min. sec.	h. min. sec.	
1	9 29 18·6	9 34 55·6	
2	- -	9 44 50·8	
3	9 49 22,0	9 54 53·6	
4	9 59 17,2	10 04 53,2	
5	10 09 22,:	10 15 08,8	—
6	10 19 41',6	10 24 48,4	
7	10 29 28,6	10 34 58,8	
8	- -	10 44 57,6	
9	Eclair.	10 54 48,0	
10	Eclair.	11 04 48,8	

III. *Colonel* BONNE'S *observations of signals seen from Lignieres.*

Chronometer Motel, No. 39.

Observations du 19 Juillet, le neuvième jour.			
	Apparition des Signaux, en tems de la montre. à l'Orient.	à l'Occident.	Remarques.
	h. min. sec.	h. min. sec.	
1			
2	- -	9 44 49·4	
3	- -	9 54 49·8	
4			—
5	10 09 39·4	10 14 50,4	
6			
7	- -	10 34 49·8	
8			
9	10 49 41,0	10, 54 53,2	
10	10 59 30,8	11 05 01,0	

Observations du 20 Juillet, le dixième jour.			
	Apparition des Signaux, en tems de la montre. à l'Orient.	à l'Occident.	Remarques.
	h. min. sec.	h. min. sec.	
1			
2			
3	9 49 29,6		
4		—	—
5	10 09 28,0		
6			
7			
8			
9	10 49 31,2		
10			

Colonel Bonne's *observations of signals seen from Lignieres.*

Observations du 21 Juillet, le 11me jour.

	Apparition des Signaux, en tems de la montre.		Remarques.
	à l'Orient.	à l'Occident.	
	h. min. sec.	h. min. sec.	
1	- -	9 34 50,8	
2	9 39 24,6		
3	9 49 32,6		
4	- -	10 04 53,0	—— ——
5	10 09 38,8		
6			
7	- -	10 34 49,6	
8	- -	10 44 59,4	
9			
10	10 59 33,4	11 04 51,6	

Observations du 22 Juillet, le 12me jour.

	Apparition des Signaux, en tems de la montre.		Remarques.
	à l'Orient.	à l'Occident.	
	h. min. sec.	h. min. sec.	
1	9 29 16,4	9 34 55,4	
2			
3	9 49 21,8	9 54 53,4	
4	9 59 17,0	10 04 53,	—— ——
5	10 09 21,4	10 15 08,4	
6	10 19 41,8	10 24 48,2	
7	10 29 28,2	10 34 58,6	
8	- -	10 44 57,4	
9	10 49 23,	10 54 47,4	
10	10 59 25,8	11 04 48,8	

IV. *Observations of the signals at the Fairlight Station, by Mr.* Herschel.

By Baker's Chronometer, No. 744. Going M. T. beating half seconds.

First Day's Observations, July 11, 1825.

No.		h. m. s.	Remarks.
1	La Canche	——	
	Wrotham	- -	Seen, but the time not seized correctly.
2	La Canche	——	
	Wrotham	9 41 7·6	The train began at 9h 41m 2s.
3	La Canche	——	
	Wrotham	9 51 3·5	Train began at 9h 20m 59s·5.
4	La Canche	9 56 23·2	Seen by the gunners with naked eye.
	Wrotham	10 1 4·8	Very good.
5	La Canche	10 5 59·2	Faint and indistinct. Seen by the gunners.
	Wrotham	10 11 3·0	Precise.
6	La Canche	——	
	Wrotham	10 21 4·4	Train began at 59s.0.
7	La Canche	——	
	Wrotham	10 31 4·7	Train began at 58s·5.
8	La Canche	10 36 15·8	Very faint. Not seen by the men.
	Wrotham	9 41 6·3	
9	La Canche	10 46 12·4	Seen by the men.
	Wrotham	10 51 3·3	
10	La Canche	——	
	Wrotham	11 1 8·2	

Second Day's Observations, July 12, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 24·5	
	Wrotham	9 36 7·3	Not the true explosion according to M. Largeteau.
2	La Canche	9 36 23·3	Very bright and sharp.
	Wrotham	9 41 7·5	
3	La Canche	——	Lost by looking the wrong way.
	Wrotham	——	
4	La Canche	9 56 17·8	Distinct.
	Wrotham	10 1 8·8	Sharp and bright.
5	La Canche	10 6 31·7	Extremely faint. Doubtful.
	Wrotham	10 11 9·2	Bright.
6	La Canche	10 16 23·6	Distinct.
	Wrotham	10 21 10·0	Bright.
7	La Canche	10 26 22 5	Seen by Mr. Gilbert with naked eye.
	Wrotham	10 31 8·0	Bright.
8	La Canche	10 36 21·9	
	Wrotham	10 41 8·1	Train began at 1s.
9	La Canche	10 46 16·5	? 15s.5. The decimal correct.
	Wrotham	10 51 5·4	Train began at 0s.5.
10	La Canche	10 56 16·4	Very bright. Train seen 4 or 5s.
	Wrotham	11 1 6·6	Train began at 0s.5.

Mr. HERSCHEL'S *observations of the signals seen from Fairlight.*

Third Day, July 13, 1825.

No.		h. m. s.	Remarks.
1	La Canche	——	A thick sea-fog suddenly came on 2^{m} before the time, though perfectly clear till then.
	Wrotham	9 31 6·0::	A mere suspicion. Fog thicker.
2	La Canche	——	Fog.
	Wrotham	——	Fog.
3	La Canche	——	Fog.
	Wrotham	9 51 12·5	Very faint, but distinct. Fog clearing.
4	La Canche	9 56 27·6	Distinct.
	Wrotham	——	Object-glasses examined. All covered with moisture from the fog.
5	La Canche	10 6 28·5	Well observed. Train seen.
	Wrotham	10 11 16·5	Perfectly well seen.
6	La Canche	10 16 18·1	
	Wrotham	10 21 14·1	Well seen; but the glass dim, and the fog coming on again.
7	La Canche	——	Fog suddenly came on again, and is surprisingly dense, so as scarcely to allow the Mill to be seen; yet the stars are clear to within 10 degrees of the horizon.
	Wrotham	——	
8	La Canche	——	
		——	
9	Wrotham	——	Fog.
	La Canche	——	Fog.
10	Wrotham	——	Fog.
	La Canche	——	Fog.

Fourth Day, July 14, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 22·7	Very distinct; train seen.
	Wrotham	9 31 15·1	A pretty strong breeze.
2	La Canche	9 36 15·3	Train perfectly well seen.
	Wrotham	9 41 16·4	
3	La Canche	9 46 28·1	Train seen.
	Wrotham	9 51 15·2	
4	La Canche	9 56 17·4	Train seen. Wind increasing.
	Wrotham	10 1 15·4	
5	La Canche	10 6 21·5	
	Wrotham	10 11 19·6	
6	La Canche	10 16 24·5	? $23^{s}.5$—am almost sure $23^{s}·5$ is the right.
	Wrotham	10 21 18·8	
7	La Canche	10 26 25·0	
	Wrotham	10 31 15·2	Exploded irregularly at half its height.
8	La Canche	10 36 17·5	Train *not* seen. N. B. A star in the field of the glass.
	Wrotham	10 41 18·5	
9	La Canche	10 46 27·8	First a bright spark; then the train; then long after, a feeble explosion at $27^{s}.8$. The first flash was brighter than the explosion.
	Wrotham	10 51 16·6	
10	La Canche	10 56 19·7	Train feebly seen.
	Wrotham	11 1 17·8	

Fifth Day, July 15, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 30·4	The first flash seen at $19^{s}.4$ on lighting the rocket. The flash at $30^{s}·4$ very bright.
	Wrotham	9 31 22·3	
2	La Canche	9 36 23·4	Fainter than the 1st flash of No. 1.
	Wrotham	9 41 23·2	A slight flash at lighting. The rocket did not rise.
3	La Canche	9 46 24·2	A flash at $16^{s}·3$ low down. The flash at $24^{s}·2$ higher, and to the right of the former. (The telescope inverts. N. B.)
	Wrotham	——	
4	La Canche	9 56 25·2	Faint, but very distinct.
	Wrotham	10 1 18·0::	
5	La Canche	10 6 23·5	Signal regular and distinct, but observation uncertain from a violent noise in the adjoining field.
	Wrotham	10 11 23·4	
6	La Canche	10 16 18·1	Sharp and good, but low.
		10 16 25·2	Feeble and high, to the right of the former.
	Wrotham	10 21 22·0	Certainly ·0, but the second uncertain, from a violent noise which drowned the beat of the watch.
7	La Canche	10 26 22·5	Noise continued, and the observations uncertain on account of it.
	Wrotham	10 31 25·9	
8	La Canche	10 36 25·3	Single explosion; well observed.
	Wrotham	10 41 23·3	Well observed.
9	La Canche	10 46 25·4	Single explosion; extremely f.
	Wrotham	10 51 23·4	Well observed.
10	La Canche	10 56 21·5	
	Wrotham	——	The train seen. No explosion. The signal not repeated.

Sixth Day, July 16, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 26·3	Extremely faint.
	Wrotham	9 31 31·4	The decimal correct, the second possibly erroneous from noise.
2	La Canche	9 36 19·1	Small bright spark.
		24·3	Broad feeble flash, higher, and to the apparent right
	Wrotham	9 41 30·0	Exact on the beat.
3	La Canche	9 46 38·0	Single bright flash.
	Wrotham	9 51 26·1	Explosion distinct but unexpected, as it happened before the rocket reached its greatest elevation.
4	La Canche	——	
	Wrotham	10 1 31·6	Regular, and well observed.
5	La Canche	——	
	Wrotham	10 11 30·8	Regular, and well observed.
6	La Canche	10 16 32·2	Bright single flash.
	Wrotham	10 21 32·7	
7	La Canche	10 26 21·5	Excessively faint.
	Wrotham	10 31 29·1	
8	La Canche	10 36 27·2	Extremely faint.
	Wrotham	10 41 35·9	
9	La Canche	10 46 18·2	Very bright.
	Wrotham	10 51 29·9	
10	La Canche	10 56 29·6	Very bright. Observed with M. LARGETEAU'S glass; a doubt having arisen as to its correct pointing, he having seen none of the La Canche signals this evening.
	Wrotham	11 1 29·7	

Mr. Herschel's *observations of the signals seen from Fairlight.*

Seventh Day, July 17, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 20·6	
	Wrotham	9 31 36·3	
2	La Canche	9 36 20·5	Excessively faint but instantaneous.
	Wrotham	9 41 35·9	
3	La Canche	9 46 27·0	:: A mere suspicion.
	Wrotham	9 51 37·2	
4	La Canche	9 56 28·0	Well observed.
	Wrotham	10 1 37·6	
5	La Canche	10 6 28·2	Telescope put in focus by a *.
	Wrotham	10 11 35·7	
6	La Canche	10 16 29·5	Extr. faint, like a * of 10 m.
	Wrotham	10 21 38·9	Exactly observed.
7	La Canche	10 26 27·8	Very distinct; perfectly well observed.
	Wrotham	10 31 41·0	
8	La Canche	10 36 24·5	:: A pretty strong suspicion.
	Wrotham	10 41 41·1	
9	La Canche	10 46 38·5	The second doubtful, owing to the lateness of the explosion.
	Wrotham	10 51 31·7	
10	La Canche	10 56 30·2	::: A faint suspicion.
	Wrotham	11 1 38·7	

Eighth Day, July 18, 1825.

No.		h. m. sec.	Remarks.
1	La Canche	——	
	Wrotham	9 31 41·9	Good.
2	La Canche	9 36 30·9	Good.
	Wrotham	9 41 46·0	Good.
3	La Canche	9 46 29·7	Good.
	Wrotham	9 51 49·5	Good.
4	La Canche	9 56 32·8	Good.
	Wrotham	10 1 50·3	Good.
5	La Canche	10 6 31·4	Good.
	Wrotham	10 11 48·6	Good. Uncommonly bright.
6	La Canche	10 16 32·3	Good.
	Wrotham	10 21 47·0	Good.
7	La Canche	10 26 23·4	Unexpected; possibly 1s wrong.
	Wrotham	10 31 42·8	Good.
8	La Canche	——	
	Wrotham	10 41 47·2	
9	La Canche	10 46 27·0	:: Ill observed.
	Wrotham	10 51 43·1	
10	La Canche	10 56 24·9	Perfectly well observed.
	Wrotham	11 1 42·0	

Ninth Day, July 19, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 31·3	or 34·3, certainly one or the other.
	Wrotham	9 31 51·5	Very brilliant.
2	La Canche	9 36 33·0	Very bright; well observed.
	Wrotham	9 42 0·5	Remained extremely long in the air, & mounted to a vast height.
3	La Canche	9 46 33·8	
	Wrotham	9 51 53·8	
4	La Canche	9 56 29·1	
	Wrotham	10 1 56·4	
5	La Canche	——	Missed by looking into the wrong telescope by mistake.
	Wrotham	10 11 51·1	Burst without rising.
6	La Canche	10 16 32·2	Train seen before the flash.
	Wrotham	10 22 2·5	Two rockets fired. The first burst, the second observed as here set down.
7	La Canche	10 26 33·7	Train seen as well as flash.
	Wrotham	10 32 24·8	
8	La Canche	10 36 35·0	Extremely faint; the train as bright as the flash.
	Wrotham	10 41 59·7	Very bright.
9	La Canche	10 46 37·6	Train seen.
	Wrotham	10 51 59·8	Mounted to an immense height.
10	La Canche	10 56 29·5	The first flash at lighting observed; a second flash a long while after, seen, but time not taken.
	Wrotham	11 1 51·0	First flash, rocket burst.
		2 3·5	Second rocket, rose regularly.

Tenth Day, July 20, 1825.

No.		h. m. s.	Remarks.
1	La Canche	——	
	Wrotham	9 31 43·3	
2	La Canche	9 36 36·2	
	Wrotham	9 41 58·0	
3	La Canche	9 46 37·9	Single flash.
	Wrotham	9 51 56·0	
4	La Canche	——	
	Wrotham	10 1 56·7	
5	La Canche	10 6 44·1	Single p. bright flash.
	Wrotham	10 11 57·9	Single flash; train not seen.
6	La Canche	——	
	Wrotham	10 22 4·4	
7	La Canche	——	
	Wrotham	10 31 58·1	
8	La Canehe	——	
	Wrotham	10 41 58·0	A second fired, but both were bad signals. Observation of little value.
9	La Canche	——	
	Wrotham	10 51 58·0	Large flash; some seconds after a small faint one.
10	La Canche	——	
	Wrotham	11 1 58·5	

Mr. HERSCHEL'S *observations of the signals seen at Fairlight.*

Eleventh Day, July 21, 1825.

No.		h. m. sec.	Remarks.
1	La Canche	———	A most favourable night, and transparent atmosphere.
	Wrotham	———	Three rockets fired, but all burst, and none could be observed.
2	La Canche	9 36 36·1	
	Wrotham	9 42 7·7	Good. The rocket rose regularly.
3	La Canche	9 46 39·0	Excellent.
	Wrotham	9 52 2·5 3·0 3·5	Three rockets fired in close succession, all burst.
4	La Canche	9 56 41·5	
	Wrotham	10 2 2·7 8·0	or 1·7 Both burst without rising.
5	La Canche	10 6 39·8	
	Wrotham	10 12 1·0 8·9	Both well observed, but both burst without rising.
6	La Canche	10 16 37·7	Excessively feeble, but certain.
	Wrotham	10 22 1·5 8·8	Both burst without rising.
7	La Canche	10 26 28·3	
	Wrotham	10 — — 32 8·4	Two fired; the first missed; both burst.
8	La Canche	10 36 47·9	Very good; train seen; the rocket remained very long in the air.
	Wrotham	10 42 1·1 2·0	Both burst.
9	La Canche	10 46 41·9	
	Wrotham	10 52 2·5 22·0	Both burst.
10	La Canche	10 56 41·1	
	Wrotham	11 2 1·0	One only, which burst; being the 19th out of 20 fired to night.

Twelfth Day, July 22, 1825.

No.		h. m. s.	Remarks.
1	La Canche	9 26 35·5	Very bright and fine.
	Wrotham	9 32 9·0	Regular and good.
2	La Canche	9 36 39·8	Train well seen.
	Wrotham	9 42 7·0	Regular and well observed.
3	La Canche	9 46 42·5	Train seen. Rose to a vast height.
	Wrotham	9 52 8·6	Regular and well observed.
4	La Canche	9 56 42·5	Very good.
	Wrotham	10 2 10·1	Perfect observation.
5	La Canche	10 6 58·0	Very exact.
	Wrotham	10 12 0·7	Burst without rising.
6	La Canche	10 26 48·2	
	Wrotham	10 32 3·0 8·9	Two fired; both burst.
7	La Canche	10 26 48·2	
	Wrotham	10 32 3·0 8·9	Both burst.
8	La Canche	10 36 47·0 58·8	——— Rose regularly, but rather a doubtful observation.
	Wrotham	10 42 1·0 7·2 —	All three burst.
9	La Canche	10 46 36·9	Single. Train seen.
	Wrotham	10 52 2·0 8·7	Both burst.
10	La Canche	10 56 38·0 43·5	: : Doubtful.
	Wrotham	11 2 2·8	Burst.

V. *Copie des Observations à Fairlight Down par* C. L. LARGETEAU.

1825. (BAKER'S Chronometer, N°. 744.)

12 Juillet.

No.		h. m. sec.	Remarks.
1	La Canche	———	
	Wrotham	———	
2	La Canche	9 36 22·9	
	Wrotham	9 41 7·9	
3	La Canche	———	
	Wrotham	9 51 7·0	
4	La Canche	9 56 17·8	
	Wrotham	10 1 8·6	
5	La Canche	10 6 31·7	
	Wrotham	10 11 9·4	
6	La Canche	10 16 23·8	
	Wrotham	10 21 10·0	
7	La Canche	10 26 22·5	
	Wrotham	10 31 7·9	
8	La Canche	10 36 21·9	
	Wrotham	10 41 8·3	
9	La Canche	10 46 16·5	
	Wrotham	10 51 5·1	
10	La Canche	10 56 15·9	
	Wrotham	11 1 11·7	il faut peut être $11^h\ 1^m\ 6.7^s$

13 Juillet.

No.		h. m. s.	Remarks.
1	La Canche	———	
	Wrotham	———	
2	La Canche	———	
	Wrotham	———	
3	La Canche	———	
	Wrotham	———	
4	La Canche	9 56 27·3	
	Wrotham	———	
5	La Canche	10 6 28·5	———
	Wrotham	10 11 14·6	
6	La Canche	10 16 17·9	
	Wrotham	10 21 14·0	
7	La Canche	———	
	Wrotham	———	
8	La Canche	———	
	Wrotham	———	
9	La Canche	———	
	Wrotham	———	
10	La Canche	———	
	Wrotham	———	

M. Largeteau's *Observations at Fairlight continued.*

14 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	9 26 22·7	
	Wrotham	9 31 15·3	
2	La Canche	—	
	Wrotham	9 41 16·6	
3	La Canche	9 46 28·0	
	Wrotham	9 51 15·0	
4	La Canche	9 56 17·4	
	Wrotham	10 1 15·4	
5	La Canche	10 6 21·8	
	Wrotham	10 11 19.5	—
6	La Canche	10 16 23.6	
	Wrotham	10 21 18·9	
7	La Canche	10 26 25·0	
	Wrotham	10 31 15·3	
8	La Canche	—	
	Wrotham	10 41 18·5	
9	La Canche	10 46 27·8	
	Wrotham	10 51 16·4	
10	La Canche	10 56 20·0	
	Wrotham	11 1 17·9	

15 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	—	
	Wrotham	9 31 22·4	
2	La Canche	—	
	Wrotham	9 41 23·0	
3	La Canche	9 46 24·8	
	Wrotham	—	
4	La Canche	—	
	Wrotham	—	
5	La Canche	—	
	Wrotham	10 11 23·4	—
6	La Canche	—	
	Wrotham	10 21 22·5	
7	La Canche	—	
	Wrotham	10 31 25·4	
8	La Canche	10 36 25.3	
	Wrotham	10 41 23·3	
9	La Canche	10 46 25·3	
	Wrotham	10 51 23·2	
10	La Canche	—	
	Wrotham	—	

16 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	—	
	Wrotham	9 31 31·3	
2	La Canche	—	
	Wrotham	9 41 29·9	
3	La Canche	—	
	Wrotham	9 51 25·8	
4	La Canche	—	
	Wrotham	10 1 31·5	
5	La Canche	—	
	Wrotham	10 11 30·7	—
6	La Canche	—	
	Wrotham	10 21 32·6	
7	La Canche	—	
	Wrotham	10 31 28·9	
8	La Canche	—	
	Wrotham	10 41 35·3	
9	La Canche	—	
	Wrotham	10 51 30·0	
10	La Canche	10 56 29·7	
	Wrotham	11 1 29·8	

17 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	9 26 20·8	
	Wrotham	9 31 36·0	
2	La Canche	9 36 20·3	Faible.
	Wrotham	9 41 35·9	
3	La Canche	—	
	Wrotham	9 51 37·0	
4	La Canche	9 56 27·7	
	Wrotham	10 1 37·4	
5	La Cancbe	10 6 27·9	Faible.
	Wrotham	10 11 35·6	
6	La Canche	—	
	Wrotham	10 21 38·8	
7	La Canche	10 26 27·7	
	Wrotham	10 31 40·7	
8	La Canche	10 36 24·8	Faible.
	Wrotham	10 41 40·8	
9	La Canche	10 46 38·5	Faible.
	Wrotham	10 51 32·0	
10	La Canche	—	
	Wrotham	11 1 38·4	

M. LARGETEAU's *Observations at Fairlight continued.*

18 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	———	
	Wrotham	———	
2	La Canche	9 36 31·0	
	Wrotham	9 41 46·4	
3	La Canche	9 46 29·8	Faible.
	Wrotham	9 51 49·7	
4	La Canche	9 56 32·5	
	Wrotham	———	
5	La Canche	———	
	Wrotham	———	
6	La Canche	10 16 32·2	
	Wrotham	10 21 46·8	
7	La Canche	10 26 24·5	Faible, Observation douteuse
	Wrotham	10 31 42·5	Observation douteuse
8	La Canche	———	
	Wrotham	10 41 47·2	
9	La Canche	10 46 30·3	Observation douteuse
	Wrotham	10 51 43·0	
10	La Canche	10 56 25·0	
	Wrotham	11 1 42·4	

19 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	———	
	Wrotham	9 31 50·5	Observation douteuse
2	La Canche	9 36 33.2	
	Wrotham	9 42 0·4	
3	La Canche	9 46 33·5	
	Wrotham	9 51 53·5	
4	La Canche	9 56 28·8	
	Wrotham	10 1 56·6	
5	La Canche	———	
	Wrotham	10 11 50·5	Observation douteuse
6	La Canche	10 16 32·5	
	Wrotham	10 22 2·4	
7	La Canche	10 26 33·7	
	Wrotham	10 32 24·7	ou 14.7.″
8	La Canche	10 36 35·1	Extremement faible.
	Wrotham	10 41 59·9	
9	La Canche	10 46 37·5	
	Wrotham	10 51 59·4	
10	La Canche	———	
	Wrotham	11 2 3·3	

20 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	———	
	Wrotham	9 31 43·5	
2	La Canche	———	
	Wrotham	9 41 58·2	
3	La Canche	———	
	Wrotham	9 51 56·4	
4	La Canche	———	
	Wrotham	10 1 56·5	
5	La Canche	———	
	Wrotham	10 11 57·8	
6	La Canche	———	
	Wrotham	10 22 4·5	
7	La Canche	———	
	Wrotham	10 31 57·7	
8	La Canche	———	
	Wrotham	10 41 58·3	incertaine.
9	La Canche	———	
	Wrotham	10 51 57 9	incertaine.
10	La Canche	———	
	Wrotham	———	

21 Juillet.

No.		h. m. s.	Remarques.
1	La Canche	———	
	Wrotham	———	
	La Canche	9 36 36·0	
	Wrotham	9 42 7·6	
3	La Canche	9 46 38·9	Faible.
	Wrotham	———	
4	La Canche	———	
	Wrotham	———	
5	La Canche	10 6 39·8	
	Wrotham	10 12 0·4	1ere Explosion.
		———	2e
6	La Canche	———	
	Wrotham	———	
7	La Canche	10 26 38·2	
	Wrotham	10 32 1·9	1ere Explosion.
		8 5	2e
8	La Canche	10 36 47·9	
	Wrotham	10 42 0·9	1ere Explosion.
		———	2e
9	La Canche	10 46 41·8	
	Wrotham	10 52 2·3	1ere Explosion
		21·5	2e
10	La Canche	———	
	Wrotham	10 2 1·1	

M. Largeteau's *observations at Fairlight continued.*

22 Juillet.						
No.		h.	m.	s.	Remarques.	
1	La Canche	9	26	35·3		
	Wrotham	9	32	8·9		
2	La Canche	9	36	39·8		
	Wrotham	9	42	6·9		
3	La Canche	9	46	42·4		
	Wrotham	9	52	8·5		
4	La Canche	———				
	Wrotham	10	2	9·7		
5	La Canche	10	6	57·7		
	Wrotham	10	12	0·7	Douteuse	
6	La Canche	10	16	37·7		
	Wrotham	10	22	1·8	1ere Explosion	Obs. incertaine.
				8·0	2e	
				——	3e	
7	La Canche	10	26	47·9		
	Wrotham	10	32	2·7	1ere Explosion	Obs. incertaine.
				9·1	2e	
8	La Canche	10	36	59·0	Douteuse.	
	Wrotham	———				
9	La Canche	10	46	37·4		
	Wrotham	———				
10	La Canche	10	56	37·8	Très douteuse.	
	Wrotham	11	2	2·7		

VI. *Observations made at the top of the Royal Observatory, Greenwich, on the rockets at Wrotham.*

July 11, 1825. The blue light and all the rockets were this evening distinctly seen by the naked eye. The observations were made with telescopes, by three observers, with the same chronometer. The chronometer was compared with the transit clock both before and after observation. The blue light appeared about $9^h\ 21^m\ 25^s$.

Rockets.	Appt Time I.	- - - II.	- - - III.	Mean *
1	$9^h\,31^m\,54.4^s$	- - 54.3^s	- - 54.2^s	54.30^s
2	9 41 49.25	- - 49.4	- - 49.2	49.28
3	9 51 45.75	- - 46.2	- - 45.8	45.92
4	10 1 47.5	- - 47.8	- - 47.4	47.56
5	———	- - 45.8	- - 45.4	45.60
6	10 21 46.75	- - 47.1	Absent.	46.92
7	10 31 46.8	- - 47.2	- - 47.3	47.10
8	———	- - 49·0	- - 48.4	48.70
9	10 51 45.8	- - 46.3	- - 46.2	46.10
10	11 1 50.4	- - 50.5	- - 50.6	50.50

	Chronometer	Clock.
Comparison before - -	$8^h\ 55^m$	$16^h\ 12^m\ 22^s.06$
after - -	11 14	18 31 44.67

** Mean Error and Rate of Sidereal Clock.

Mean of transits of 5 * s	Corresponding mean error.	Rate.
$16^h\ 24^m$	48.36^s	— 0.02

Chronometer fast $1^m\ 17.97^s$.

The loss of the fifth observation in column 1. was occasioned by some accidental derangement of the telescope. The loss of the eighth was occasioned by the rocket passing through the field of view before explosion. Observations 9 and 10, in column 1, were made with the naked eye.

* In taking the mean of the three observations, those marked (: :) doubtful, are not considered.

** The transit observations employed throughout are reduced by the same system of corrections, and mean right ascensions, as those used at the observatory of Paris for that purpose; so that no error in the results, from a difference of catalogues or corrections, is introduced.

July 12. All the signals, the blue light excepted, were this evening visible to the naked eye; the blue light could not be seen at all:* the times of the explosions were this evening *all* observed with telescopes.

Rockets.	Appt Time. I.	- - II.		Mean.
: 1	9^h 31 50^s	9^h $31^m 49.8^s$	This evening no third observer.	49.90^s
2	41 50.75	41 50.6		50.67
3	51 50.0	51 50.0		50.00
4	10 1 51.5	10 1 51.5		51.50
5	11 51.8	11 52.2		52.00
: 6	21 53.0	21 52.8		52.90
7	31 51.0	31 51.0		51.00
8	41 51.2	41 51.3		51.25
9	51 48.0	51 48.0		48.00
10	11 1 49.8	11 1 49.7		49.75

	Chronometer.	Clock.
Comparison before -	9^h 11^m	16^h 32^m 19.94^s
After -	11 12	18 33 39.80

Mean Error and Rate of Transit Clock.

Mean of 5 * s	Corresponding error.	Rate.
16^h 24^m	48.27^s	— 0.08

From mean comparison on 11th, to ditto on 12th, chronometer gained 1.02^s.
Chronometer fast 1^m 18.99^s.

Rockets 1 and 6 exploded twice, at an interval of about three seconds. The first explosion, in each case, was the one observed; the second, not being expected, was lost.

* None was fired. (H.)

July 13th. All the signals were visible to the naked eye.

Rockets.	App^t Time I.	- - II.	- - III.	Mean.
1	$9^h\ 31^m\ 55.8^s$	$9^h\ 31^m\ 55.6^s$	55.6^s	55.67^s
2	——	——	——	—
3	9 51 55.75	51 56.0	: : - 55.2	55.87
4	10 1 55.0	10 1 55.2	- - 54.8	55.0
5	11 57.4	11 57.3	- - 57.6	57.43
6	21 57.2	21 57.0	- - 57.0	57.07
7	31 56.6	31 56.6	- - 56.5	56.57
8	41 56.0	41 56.0	- - 55.8	55.93
9	51 55.8	51 55.6	- - 55.3	55.57
10	- - -	11 1 56.2	- - 56.2	56.2

Chronometer.

Comparison.			
	Before -	$9^h\ 16^m$	$16^h\ 41^m\ 16.63^s$
	After - -	11 13	18 38 35.75

Mean Error and Rate of Sidereal Clock.

Mean of 6 *s	Mean error corresponding.	Mean rate.
$16^h\ 40^m$	48.39^s	+ 0.14

Comparison 12th to ditto 13th. Chronometer, + 0.87.
Chronometer fast $1^m\ 19.86^s$.

The 2d rocket was lost by all the observers: it did not appear till some seconds after the time specified; and when it did appear it exploded immediately. It exploded *about* $9^h\ 42^m\ 22^s$.

The 10th rocket in column I. was lost by a derangement of the telescope.

The third observation, column III. is doubtful to half a second.

July 14.

Rockets.	Appt Time I.	- - II.	- - III.	Mean.
1	$9^h\ 31^m\ 59.0^s$	– – 59.2^s	- -	59.10^s
2	42 0.7	– – 0.4	- -	0.55
3	51 59.0	– – 59.0	- -	59.00
4	::10 1 58.8	– – 59.4	- Absent. -	59.40
5	12 3.4	– – 3.3	- -	3.35
6	22 3.2	– – 3.1	- -	3.15
7	31 59.4	– – 59.2	- -	59.30
8	42 2.4	– – 2.3	- -	2.35
9	52 0.3	– – 0.5	- -	0.5
10	11 2 1.8	– – 2.0	- -	1.9

Comparison of Chronometer and Clock.

	Chronometer	Clock.
Before - -	$9^h\ 11^m$	$16^h\ 40^m\ 11.87^s$
After - -	11 15	18 44 32.13

Mean Error, and Rate of Sidereal Clock.

Mean of 7 *s	Mean error corresponding.	Mean rate.
$16^h\ 21^m$	48.25^s	—0.16

Comparison 13th to ditto 14th + 0.38.
Chronometer fast $1^m\ 20.24^s$.

July 15th. The third, fourth, and last rockets disappeared without any explosion. In the third column something like an explosion was noted at the beginning of the ascent of the third rocket, but no dependance can be placed on it.

Rockets.	Appt Time. I.	- - II.	- - III.	Mean.
1	$9^h\ 32^m\ 8.6^s$	– – 8.5^s	– – 8.4^s	8.5^s
2	42 8.8	– – 9.0	– – 9.0	8.93
3	———	———	———	—
4	———	———	::10 2 3.0	—
5	10 12 9.4	– – 9.0	– – 9.2	9.20
6	22 8.1	– – 8.0	– – 8.0	8.03
7	32 10.9	– – 11.2	– – 11.5	11.2
8	42 9.3	– – 9.2	– – 9.2	9.23
9	52 9.2	– – 9.0	– – 9.0	9.07
10	———	———	———	—

Comparison of Chronometer and Clock.

	Chronometer.	Clock.
Before - -	$9^h\ 24^m$	$16^h\ 57^m\ 9.80^s$
After - -	11 10	18 43 27.04

Mean Error, and Rate of Sidereal Clock.

Mean of 6 *s	Mean error corresponding.	Mean rate.
$16^h\ 0^m$	47.92^s	— 0.30

Comparison 14th to ditto 15th + 0.47
Chronometer fast $1^m\ 20.71^s$.

July 16. The third rocket disappeared without explosion.

Rockets.	App^t^ Time. I.	- - II.	- - III.	Mean.
1	$9^h\,32^m\,17.0^s$	- - 16.9^s	- - 16.9^s	16.93^s
2	42 15.6	- - 15.6	- - 15.4	15.53
3	—	—	—	—
4	10 2 16.8	- - 17.2	- - 17.1	17.03
5	12 16.4	- - 16.3	- - 16.5	16.40
6	22 18.0	- - 17.9	- - 18.3	18.07
7	32 14.9	- - 14.8	- - 15.1	14.93
8	42 21.0	- - 21.0	- - 21.0	21.0
9	52 15.8	- - 15.2	- - 15.4	15.47
10	11 2 15.2	- - 15.1	- - 15.5	15.27

Comparison of Chronometer and Clock.

Chronometer.	Clock.
Before $9^h\,18^m$	$16^h\,55^m\,5.29^s$
After 11 12	18 49 24.06

Mean Error and Rate of Sidereal Clock.

Mean of 5 *s	Mean error corresponding.	Mean rate.
16.6	47.60^s	-0.33^s

Comparison from 15th to 16th — 0.31.

Chronometer fast $1^m\,20.40^s$.

July 17th. The loss of observation 1, in columns I. and III. was occasioned by the observers mistaking the minute. It was however very accurately taken by the second observer.

Rockets.	App^t Time I.	- - II.	- - III.	Mean.
1	——	$9^h\ 32^m\ 20.1^s$	——	20.1^s
2	$9^h\ 42^m\ 20.0^s$	42 19.9	:: $-^h$ $-^m$ 19.1^s	19.95
3	52 20.8	- - 21.3	- - 21.3	21.13
4	10 2 21.4	- - 21.4	- - 21.4	21.40
5	12 19.8	- - 19.3	- - 19.2	19.43
6	22 22.9	- - 22.8	- - 22.9	22.87
7	32 24.8	- - 24.8	- - 24.8	24.8
8	42 25.0	- - 25.0	- - 25.0	25.0
9	- - -	- - -	:: 10 52 16.0	—
10	11 2 22.5	- - 22.6	- - 22.6	22.57

Comparison of Chronometer and Clock.

Chronometer.	Clock.
Before $9^h\ 21^m$	$17^h\ 2^m\ 3.68^s$
After 11 11	18 52 21.72

Mean Error and Rate of Sidereal Clock.

Mean of 7 *s	Mean error.	Mean rate.
$15^h\ 30^m$	47.56^s	— 0.06

Comparison from 16th to 17th — 1.40.
Chronometer fast $1^m\ 19.00^s$

The ninth rocket exploded the moment it began to ascend: the time noted cannot be depended on.

July 18th. The first, seventh, ninth, and tenth rockets could not be observed; one or two exploded without ascending; the remainder did not explode at all.

Rockets.	App^t Time I.	- - II.	- - III.	Mean.
1	——	——	——	—
2	$9^h\,42^m\,29.1^s$	– – 29.0^s	– – 29.1^s	29.07^s
3	– 52 32.1	– – 32.3	– – 32.2	32.20
4	10 2 33.3	– – 33.0	– – 33.2	33.17
5	– 12 31.1	– – 31.0	– – 31.6	31.23
6	– 22 29.8	– – 29.6	– – 29.7	29.70
7	——	——	——	—
8	– 42 29.9	– – 30.0	– – 29.9	29.93
9	——	——	——	—
10	——	——	——	—

Comparison of Chronometer and Clock.

Chronometer.	Clock.
Before $9^h\,37^m$	$17^h\,22^m\,3.55^s$
After 11 11	18 56 18.95

Mean Error and Rate of Sidereal Clock.

Mean of 6 ✱^{s}	Mean error.	Mean rate.
$16^h\,0^m$	47.30^s	-0.26^s

Comparison from the 17th to 18th -0.93.
Chronometer fast $1^m\,18.07^s$.

July 19th. The fifth rocket could not be observed.

Rockets.	App^t Time I.	- - II.	- - III.	Mean.
1	$9^h\ 32^m\ 43.1^s$	- - 43.0^s	- - 43.0^s	43.03^s
2	- 42 41.0	- - 40.9	- - 41.0	40.97
3	- 52 34.1	- - 34.1	- - 34.2	34.13
4	10 2 36.9	- - 36.9	- - 36.9	36.9
5	——	——	——	—
6	- 22 42.9	- - 42.9	- - 42.9	42.9
7	- 33 4.8	——	- - 4.7	4.75
8	- 42 40.1	- - 40.0	- - 40.2	40.1
9	- 52 40.0	- - 40.0	- - 39.9	39.97
10	::11 2 43.3	:: - 43.1	- - 43.7	43.7

Comparison of Chronometer and Clock.

Chronometer.	Clock.
Before $8^h\ 48^m$	$16^h\ 36^m\ 53.84^s$
After 11 10	18 59 17.02

Mean Error and Rate of Sidereal Clock.

Mean of 3 *^{s}	Mean error.	Mean rate.
$16^h\ 50^m$	47.16^s	-0.19^s

Comparison from 18th to 19th — 1.81
Chronometer fast $1^m\ 16.26^s$

Observation 10 in columns 1 and 2 doubtful to half a second.

July 20. The rockets this evening were miserably bad; five only were observed; the eighth however *might* have been a good one; it was lost by all the observers looking for it too late.

Rockets.	Appt Time I.	- - - II.	- - - III.	Mean.
1	$9^h\ 32^m\ 36.6^s$	36.7^s	36.9^s	36.73^s
2	—	—	—	—
3	52 56.2	- - 56.0	- - 56.1	56.1
4	—	—	—	—
5	—	—	10 12 39.2	39.2
6	10 22 45.7	- - 45.8	- 22 46.1	45.87
7	—	10 32 53.0	- - 53.1	53.05
8	—	—	—	—
9	—	—	—	—
10	—	—	—	—

Comparisons of Chronometer and Clock.

Chronometer.	Clock.
Before $9^h\ 6^m$	$16^h\ 58^m\ 53.06^s$
After 11 10	19 3 13.34

Mean Error and Rate of Sidereal Clock.

Mean of 5 *s	Mean error.	Mean rate
$15^h\ 40^m$	47.22^s	-0.03^s

Comparison from 19th to 20th, + 0.35
Chronometer fast $1^m\ 16.61^s$

July 21. The rockets much worse this evening than they were last. Only *one* out of the whole number mounted at all. All the others were seen, but nothing was sufficiently definite to admit of being noted. *

Rockets.	Appt Time I.	- - - II.	- - - III.	Mean.
1	—	—	—	—
2	$9^h\ 42^m\ 48.8^s$	- - 48.8^s	- - 48.8^s	48.8^s
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	—	—
7	—	—	—	—
8	—	—	—	—
9	—	—	—	—
10	—	—	—	—

Comparisons of Chronometer and Clock.

Chronometer.	Clock.
Before $9^h\ 13^m$	$1^h\ 9^m\ 50.88^s$
After 11 10	19 7 9.93

Mean Error and Rate of Sidereal Clock.

1 *s.	Error.	Rate.
$17^h\ 26^m$.	47.37	+ 0.20^s

Comparisons from 20 to 21, + 1.02
Chronometer fast $1^m\ 17.63^s$

* It is much to be regretted that some attempt at least to note them was not made. Had it been done, this night's result, which is now dependent on a single signal, might perhaps (as they were for the most part tolerably well observed at Wrotham), have been placed nearly on the same footing with the rest. H.)

July 22. Rockets extremely bad; four only could be observed.

Rockets.	Appt Time I.	- - - II.	- - - III.	Mean.
1	9h 32m 51.2s	51.35s	51.4s	51.32s
2	– 42 49.9	– – 49.8	– – 49.6	49.77
3	– 52 51.4	– – 51.3	– – 51.3	51.33
4	——	10 2 52.4	– – 52.4	52.4
5	——	——	——	—
6	——	——	——	—
7	——	——	——	—
8	——	——	——	—
9	——	——	——	—
10	——	——	——	—

Comparisons of Chronometer and Clock.

Chronometer.		Clock.
Before	9h 23m	17h 23m 48s
After	11 11	19 12 5.59

Mean Error and Rate of Sidereal Clock.

Mean of 5*s.	Mean error.	Mean rate.
15h 47m	47.57s	+ 0.21

Comparisons from 21 to 22, + 0.32.
Chronometer fast 1m 17.95s

The means of the Comparisons, with the true Sidereal Time corresponding.

	Chron.	Clock.	True Sidereal Time.
July 11	10h 4m 30s	17h 22m 3.36s	17h 21m 15.0s
12	10 11 30	17 32 59.87	17 32 11.60
13	10 14 30	17 39 56.19	17 39 7.80
14	10 15 0	17 42 22.00	17 41 33.75
15	10 17 0	17 50 18.42	17 49 30.52
16	10 15 0	17 52 14.67	17 51 27.09
17	10 16 0	17 57 12.70	17 56 25.14
18	10 24 0	18 9 11.25	18 8 23 97
19	9 59 0	17 48 5.43	17 47 18.27
20	10 8 0	18 1 3.20	18 0 15.98
21	10 11 30	18 8 30.405	18 7 42.03
22	10 17 0	18 17 56.79	18 17 9.20

True Sidereal Time of the explosions.

July 11. Rockets.	True Time.	July 12. Rockets.	True Time.	July 13. Rockets.	True Time.
1	$16^h\ 48^m\ 3.392^s$	1	$16^h\ 52^m\ 24.98^s$	1	$16^h\ 56^m\ 26.45^s$
2	— 58 30.54	2	17 2 27.38	2	——
3	17 8 28.82	3	— 12 28.27	3	17 16 29.95
4	— 18 32.11	4	— 22 31.51	4	— 26 30.73
5	— 28 31.79	5	— 32 33.66	5	— 36 34.81
6	— 38 34.85	6	— 42 36.21	6	— 46 36.09
7	— 48 36.56	7	— 52 35.93	7	— 56 37.33
8	— 58 39.80	8	18 2 37.82	8	18 6 38.23
9	18 8 38.84	9	— 12 36.19	9	— 16 39.50
10	— 18 44.8	10	— 22 39.59	10	— 26 41.77

July 14. Rockets.	True Time.	July 15 Rockets.	True Time.	July 16. Rockets.	True Time.
1	$17^h\ 0^m\ 26.10^s$	1	$17^h\ 4^m\ 31.64^s$	1	$17^h\ 8^m\ 37.06^s$
2	— 10 29.20	2	— 14 33.72	2	— 18 37.34
3	— 20 29.30	3	——	3	——
4	— 30 31.34	4	——	4	— 38 42.03
5	— 40 36.94	5	— 44 39.04	5	— 48 43.04
6	— 50 38.39	6	— 54 39.39	6	— 58 46.36
7	18 0 36.00	7	18 4 44.21	7	18 8 44.95
8	— 10 40.87	8	— 14 43.88	8	— 18 52.58
9	— 20 40.66	9	— 24 45.35	9	— 28 48.68
10	— 30 43.71	10	——	10	— 38 50.12

July 17. Rockets.	True Time.	July 18. Rockets.	True Time.	July 19. Rockets.	True Time.
1	$17^h\ 12^m\ 38.09^s$	1	——	1	$17^h\ 20^m\ 56.91^s$
2	— 22 39.58	2	$17^h\ 26^m\ 46.25^s$	2	— 30 56.55
3	— 32 44.40	3	— 36 51.02	3	— 40 51.34
4	— 42 44.30	4	— 46 53.62	4	— 50 55.77
5	— 52 43.96	5	— 56 53.31	5	——
6	18 2 49.06	6	18 6 53.42	6	18 11 5.09
7	— 12 52.63	7	——	7	— 21 28.65
8	— 22 52.48	8	18 26 57.05	8	— 31 5.58
9	——	9	——	9	— 41 7.11
10	— 42 55.29	10	——	10	— 51 12.50

July 20. Rockets.	True Time.	July 21. Rockets.	True Time.	July 22. Rockets.	True Time.
1	$17^h\ 24^m\ 46.90^s$	1	——	1	$17^h\ 32^m\ 53.27^s$
2	——	2	$17^h\ 38^m\ 56.10^s$	2	— 42 53.36
3	17 45 9.60	3	——	3	— 52 56.56
4	——	4	——	4	18 2 59.28
5	18 4 55.95	5	——	5	——
6	— 15 4.28	6	——	6	——
7	— 25 13.12	7	——	7	——
8	——	8	——	8	——
9	——	9	——	9	——
10	——	10	——	10	——

Statement of the method of combining and calculating the Observations, and obtaining the Rates of the chronometers.

Previous to stating the result of these observations, it will not be irrelevant to explain the method pursued in reducing them, and the principles on which the calculation has been made; and it may be here remarked, that the brevity and facility of the computations which will appear to be required for this purpose, is not the least recommendation of the method itself.

Suppose A and Z to be the two extreme points whose difference of longitudes is to be determined, and at each of which the true sidereal time is supposed to be known by transits of well determined stars and registered by exact clocks, or carefully compared chronometers. Intermediate between these, suppose two, or any number of stations, B, C, &c. chosen, at each of which are placed observers furnished with telescopes and good chronometers; and again, intermediate between these, and in the order

A, *a*, B, *b*, C, *c*, Z,

let posts or stations *a*, *b*, *c*, be selected, at which signals are made, by the explosion of gunpowder, the discharge of rockets, the extinction of lamps, or otherwise, at regular concerted times, and so arranged that the signals at *a* shall be visible from both A and B; those at *b* from both B and C; and those at *c* from B and Z. Now let a signal be made at *a*, and observed both from A and B, and the moment of its happening noted at A by the sidereal clock, and at B by the

chronometer; then, if the observations were perfect, the difference of the clock at A, and the chronometer at B, would become exactly known. Let this be denoted by A — B. A short time after, let a signal be made at *b*, and observed by the chronometers at B and C, whose difference (which we will in like manner denote by B — C,) becomes thus precisely known at the time of making the signal. In the same manner may the difference C — Z of the chronometer at C and the sidereal clock at Z be known at the moment of explosion of a signal at *c*; and so on, if there be more intermediate stations.

Now, the clocks at A and Z being all along supposed to keep strict sidereal time, if the watches at B, C, did the same, it is manifest that the difference between any two of them determined at one moment would be the same at every other; and therefore the intervals elapsed between the signals would be out of the question, and the observations might all be regarded as simultaneous; so that the sum of the differences $(A-B)+(B-C)+(C-Z)=A-Z$ would express strictly the difference of the true sidereal times at the extreme points, *i. e.* their difference of longitudes expressed in time, without any further calculation or reduction.

It is equally evident that, whatever be the rates of the watches, if the intervals elapsed between the signals were infinitely small, so as to reduce their gain or loss in these times to nothing, the same would hold good. Since this however cannot be the case, it is obvious that the difference of longitudes so obtained will be affected by the rates of the watches and the intervals of the signals, which must accord-

ingly be allowed for. Now, as the intervals at which the signals are made at the successive stations are small (only five minutes), the gain or loss of the watches used may be calculated for such small times to great nicety; and, if the watches were regulated to sidereal time, and of any ordinary degree of goodness, the correction on this account would be almost insensible; or, if regulated, as is generally the case, to mean time, the reduction from mean to sidereal time only need be applied, neglecting the deviation of the rates from strict mean time. The calculation then becomes of extreme simplicity; for since the watches have equal rates, we have no occasion to apply any correction to their observed differences; and it will suffice to apply to the uncorrected value of Δ ($= A - Z$, or)

$$\Delta = (A - B) + (B' - C') + (C'' - Z'')$$

the mere reduction from mean to sidereal time for the interval elapsed between the first and last signal; or in other words (regarding the whole operation as a species of telegraphing), for the time the message has occupied in its transmission from one observatory to the other.*

For example. On the 19th, a signal was made at Mont Javoult, and noted at Paris to have happened at $18^h\ 39^m\ 52^s.5$ true sidereal time at Paris, and at Lignieres at $10^h\ 49^m\ 41^s.0$ by the Lignieres Chronometer. About 5^m after this, a signal made at La Canche was observed at Lignieres to happen at $10^h\ 54^m\ 53^s.2$, and at Fairlight at $10^h\ 46^m\ 37^s.5$ by the Fairlight chronometer. Finally, a third signal was made about 5^m later still at Wrotham, and observed at $10^h\ 51^m\ 59^s.4$ by

* Might not telegraphs be employed to ascertain the difference of longitudes of the stations between which they are established?

the Fairlight chronometer, and at $18^{h}\ 41^{m}\ 7^{s}.11$ true sidereal time at Greenwich. The calculation then stands thus

$+A = +18\ \ 39\ \ 52 \cdot 50$.	$-B = -10\ \ 49\ \ 41 \cdot 00$	$B' - B = +0\ \ 5\ \ 12 \cdot 20$
$+B' = +10\ \ 54\ \ 53 \cdot 20$	$-C' = -10\ \ 46\ \ 37 \cdot 50$	$C'' - C' = +0\ \ 5\ \ 21 \cdot 90$
$+C'' = +10\ \ 51\ \ 59 \cdot 40$	$-Z'' = -18\ \ 41\ \ 7 \cdot 11$	Sum $0\ \ 10\ \ 34 \cdot 10$
Sum $= +38^{h}\ 144^{m}\ 165^{s} \cdot 10$	$-38^{h}\ 136^{m}\ 85^{s} \cdot 61$	

$= 0^{h}\ 8^{m}\ 79^{s} \cdot 49$ or $= 0^{h}\ 9^{m}\ 19^{s}.49$ the uncorrected value of Δ

Reduction from mean to Sid. T. for an interval of $10^{m}\ 34^{s} \cdot 10$ . . $= \quad + 1 \cdot 73$

$0\ \ 9\ \ 21 \cdot 22 = \Delta$

the corrected difference of longitudes.

Such is the result of the transmission of a single signal along the line, and such the whole calculation required to deduce it. It is chosen at random from among the observations, yet is probably entitled to at least as much confidence as any value hitherto previously obtained; a circumstance which sets the excellence of this method in a very strong light.

Such would be the process of calculation in the simplest state of the data, viz. when the signals are seen along the whole line without a failure, so that each message so transmitted arrives at its destination and gives a complete result. But this (in the present instance at least) has not been always, or generally the case. It has much more commonly happened that a signal made at one station (*a* for instance, has not been simultaneously observed, or not observed at all, at A and at B, while the other signals, at *b*, *c*, &c. have been regularly seen and registered. In every such case (of which endless combinations may occur) a link of the chain fails, and no result can be obtained from this series of observations taken singly. A very slight consideration will suffice to show that were we

to reject all such broken series, the observations of a whole night might easily be thrown away, though capable of affording a result quite as good as any other. Such a case actually occurs in the observations of the 18th, where no complete transmission of any one signal from end to end of the line took place, yet the mean result of that night's observations deviates less than two-tenths of a second from the result finally adopted as the truth.

The most advantageous way of employing such a broken series of observations as we have described is not at once obvious. It may depend on circumstances too nice for calculation, and which can be felt only by the observers themselves. The fairest however, and that which by employing all the observations according to one uniform rule leaves nothing to partiality, seems to me to be the following.

Let A be the time marked by the sidereal clock at the first extreme station A, then calling E the time marked by the same clock at any assumed arbitrary epoch, A—E will denote the sidereal time elapsed since that epoch. Call β the rate or sidereal time of the chronometer at the 2d station (B), β being supposed negative when the chronometer loses, (as for instance when it shows mean time). At the same moment that the clock at A marks A, let this chronometer mark B, then, since $\beta(A-E)$ is the quantity it has gained, since the epochs, $B-\beta(A-E)$ must be the time it would have indicated, if instead of gaining or losing, it had kept true sidereal time since the epoch. Consequently (the clock being supposed to have no rate) $A-\{B-\beta(A-E)\}$ or $A-B+\beta(A-E)$ will be the difference of the clock and chronometer *reduced*

to this epoch, i. e. the difference they would have indicated if instead of comparing them at the time A, they had been compared at the time E.

Every signal simultaneously observed at A and B, gives a direct comparison of the clock and chronometer; but it is only when thus reduced to a fixed epoch that these comparisons become comparable *inter se*; but when so reduced their mean may be taken, and is of course preferable to the result of any single comparison. Hence if we put

$$P = \textit{mean of all the}\,(A-B) + \beta \times \textit{mean of all the}\,(A-E)$$

P will express the difference of the clock and chronometer at the epoch more probably than any of the individual values derived from single observations.

It follows therefore that at any other sidereal time A', the time indicated by the chronometer at B, (or B') may be calculated from the expression

$$B' = (A' - P) + \beta\,(A' - E) \qquad (a)$$

more probably than it can be derived from any single actual observation. This equation gives

$$A' = \frac{B' + P + \beta E}{1 + \beta} = B' + P - \beta\,(P + B' - E)$$

neglecting squares and higher powers of β, whence the time by the clock at A becomes known at any instant in terms of that shown by the watch at B.

Now let a signal be made between B and C, and noted to happen at the moment marked B' by the watch at B, and C' by that at C. Let β and γ denote their respective rates on sidereal time; then since $B' - \beta\,(A' - E)$ and $C' - \gamma\,(A' - E)$ are the times they would have marked had they kept strict

sidereal time since the epoch, their difference *reduced* to the fixed epoch will be

$$(B'-C') - (\beta-\gamma)(A'-E)$$

in which, substituting for A its value above found, we get

$$(B'-C') - (\beta-\gamma)(P+B'-E)$$

neglecting powers and products of β and γ. Putting then $Q =$ *mean of all the* $(B'-C') - (\beta-\gamma)$ — *mean of all the* $(P+B'-E)$ we get the most probable value of the difference of the chronometers at the epoch which can be obtained from any number of such comparisons.

Finally, if we make a comparison at any time A'' (Paris Sid. T.) between the watch at C and the clock at z, and call their indications at that moment C'' and Z'', their apparent difference will be $C''-Z''$, and their difference reduced to the epoch will be

$$(C''-Z'') - \gamma(A''-E).$$

But Q being the most probable difference between the chronometers B and C at the epoch, and $(\beta-\gamma)$ the difference of their rates

$$Q + (\beta-\gamma)(A''-E)$$

will be their difference at any other moment A''; hence

$$B''-C'' = Q + (\beta-\gamma)(A''-E).$$

But by the equation (a) since B'' and A'' are corresponding times, we have

$$B'' = A''-P+\beta(A''-E).$$

Consequently substituting this for B'' we get

$$C'' = A''-P-Q+\gamma(A''-E)$$

whence

$$A'' = P+Q+C''-\gamma(A''-E)$$
$$= P+Q+C''-\gamma(P+Q+C''-E)$$

neglecting the square and higher powers of γ:

Consequently, still neglecting the same things we get

$$C'' - Z'' - \gamma \left\{ P + Q + C'' - E \right\}$$

for the difference of the timekeepers C and Z reduced to the epoch, and putting

R = *mean of all the* $(C'' - Z'') - \gamma$.*mean of all the* $(P + Q + C'' - E)$

R will be their most probable difference reduced to the fixed epoch.

P, Q, and R, being thus obtained, we must obviously have for the correct difference of longitudes,

$$\Delta = P + Q + R.$$

Now, substituting for P, Q, R, their values, this gives

$$\begin{aligned} \Delta = &\ \textit{mean of } (A - B) + \textit{mean of } (B' - C') + \textit{mean of } (C'' - Z'') \\ &+ \beta.\textit{mean of } (A - E) \\ &+ (\gamma - \beta).\textit{mean of } (P + B' - E) \\ &- \gamma.\textit{mean of } (P + Q + C'' - E) \end{aligned}$$

that is, reducing,

$$\begin{aligned} \Delta = &\ \textit{mean of } (A - B) + \textit{mean of } (B' - C') + \textit{mean of } (C'' - Z'') \\ &+ \beta.\textit{ mean of } A + (\gamma - \beta).\textit{mean of } B' - \gamma.\textit{mean of } C'' \\ &- P\beta - Q\gamma. \end{aligned}$$

This value of Δ is however susceptible of still further reduction by substituting for P and Q their values; which if done, and the powers and products of β and γ neglected, as has all along been done, we get

$$\begin{aligned} \Delta = &\ \textit{mean of } (A - B) + \textit{mean of } (B' - C') + \textit{mean of } (C'' - Z'') \\ &+ \beta.\textit{mean of } A + (\gamma - \beta)\textit{ mean of } B' - \gamma.\textit{ mean of } C'' \\ &- \beta.\textit{mean of } (A - B) - \gamma.\textit{ mean of } (B' - C') \end{aligned}$$

that is, finally (since the numbers of the observations of A and of B are necessarily equal, and therefore the mean of the values of A—B is equal to the mean of A — the mean

of B, and so for the rest) reducing and striking out all the terms which destroy each other.

$$\Delta = \textit{mean of } A - \textit{mean of } B + \textit{mean of } B' - \textit{mean of } C' + \\ + \textit{mean of } C'' - \textit{mean of } Z''$$
$$+ \beta \left\{ \textit{mean of } B - \textit{mean of } B' \right\} + \gamma \left\{ \textit{mean of } C' - \textit{mean of } C'' \right\}$$

or simply, denoting by A, B, A′, B′, &c. no longer the individual observed times (to which there will be no occasion again to refer) but the means of all those which have corresponding observations.

$$\Delta = A - B + B' - C' + C'' - Z''$$
$$+ \beta (B - B') + \gamma (C' - C''($$

This expression is, as it obviously ought to be, independent of the arbitrary epoch E, which may be assumed any number of hours or days before or after the observations.

The first line of this value of Δ may be regarded as an approximate one; the second as a correction depending on the rates of the watches; and it is clear that the several portions of which this correction consists are the respective gains of the chronometers on Sid. T. during the *mean* amounts of the delay of the message between the several stations, taking the expression in its algebraical sense, where a negative delay corresponds to an anticipation.

If all the signals succeeded, the coefficients of β and γ would be each $0^h\ 5^m$, and the amount of the correction would be $(\beta + \gamma) \cdot \frac{5^m}{24^h} = \frac{\beta + \gamma}{288}$. It would therefore require no less a deviation of one of the chronometers from its assumed rate than 29^{sec} per diem, or of both of them $14\frac{1}{2}$, and the same way, to produce an uncertainty in the result to the amount of a tenth of a second; deviations incompatible with the

character of ordinary good watches, not to speak of chronometers.

The worst case that can happen is where the *first signal only* at *a* gives corresponding observations at the stations adjacent, the *last only* at *b*, the first again *only* at *c*, and so on. In this case the coefficients of β and γ would each equal the whole interval between the first and last signal at each post, or (in the present case) $1^h\,30^m$. The correction here would be

$$1\tfrac{1}{2} \times \frac{\beta+\gamma}{24} = \frac{\beta+\gamma}{16}$$

In this extreme case, the sum of the deviations of both watches from their assumed rates, need only amount to $1^s.6$ to produce an uncertainty of a tenth of a second in the result; and though such a case as here supposed is in the last degree improbable, yet as a certain approach to it is not unlikely, it may be of use to show how the rates of the watches, if not otherwise known, may be obtained, or if known, verified, by the observations themselves.

If we consider the observations on two successive nights, at two of the extreme stations, A and B for instance, calling A and B the means of the simultaneous observations on the first night, and $A_{,}$ $B_{,}$ on the second, we have, assuming for an epoch some time $E =$ any number of days before either of the night's observations,

$$P = A - B + \beta (A - E)$$

But since this is generally true, if the observations be made in sufficient number on both nights to destroy their individual errors in the mean result, we must also have

$$P = A_{,} - B_{,} + \beta (A_{,} - E)$$

equating which we get

$$A - B - \beta (A - E) = A_{,} - B_{,} - \beta (A_{,} - E)$$

whence we find

$$-\beta = \frac{(A_{,} - B_{,}) - (A - B)}{A_{,} - A}$$

In this formula it is to be observed that $A_{,}$ and $B_{,}$ are each greater than 24 hours; but as timekeepers only register excesses above 12 hours and its multiples, if we wish to denote by $A_{,}$ and $B_{,}$ the mere readings off of the timekeepers, we must put $24^{h} + A_{,}$ and $24^{h} + B_{,}$ for $A_{,}$ and $B_{,}$ if the interval be one day; $48^{h} + A_{,}$ and $48^{h} + B_{,}$ if two days, and so on, so that (n being the number of days elapsed) we get

$$-\beta = \frac{(A_{,} - B_{,}) - (A - B)}{n \times 24^{h} + A_{,} - A}.$$

In like manner may the rate γ of the chronometer at C be found by comparison with the clock at Z thus,

$$-\gamma = \frac{(Z_{,}'' - C_{,}'') - (Z'' - C'')}{n \times 24^{h} + Z_{,}'' - Z''}.$$

If there be intermediate chronometers, the rate of each on that immediately preceding or following it may be found in exactly the same way.

Computation of the Rates of the Chronometers.

From the 18th to the 19th.

1. Lignieres Chronometer, or that at station B. Motel, No. 39.

19th.	$A_{,} - B_{,} = 7^{h}\ 50^{m}\ 7^{s}{\cdot}90$		$A_{,} = 18^{h}\ 19^{m}\ 41^{s}{\cdot}83$
18th.	$A - B = 7\ 46\ 8{\cdot}28$		$A = 18\ 32\ 21{\cdot}88$

$$(A_{,} - B_{,}) - (A - B) = +\ 3\ 59{\cdot}62 \qquad A_{,} - A = -0\ 12^{m} 40^{s}{\cdot}05$$

$$-\beta = \frac{3^{m}\ 59^{s}{\cdot}62}{24^{h} - 0^{h}\ 12^{m} 40^{s}{\cdot}05} = 4^{m}\ 1^{s}{\cdot}74\ ; \ \beta = -\ 4^{m}\ 1^{s}{\cdot}74 \div 24^{h}$$

Whence the rate *on mean time* $= -\ 5^{s}{\cdot}83$.

2. Fairlight Chronometer, at Station C. Baker, No. 744.

$$\begin{array}{llll} \text{19th.} & Z_{,} - C_{,} = 7^{h}\,49^{m}\,2^{s}\cdot75 & & Z_{,} = 18^{h}\,12^{m}\,20^{s}\cdot32 \\ & Z - C = 7\;\;45\;\;4\cdot31 & & Z = 17\;\;53\;\;32\cdot44 \\ \hline & +\;3\;\;58\cdot44 & & +0\;\;18\;\;47\cdot88 \end{array}$$

$$\beta = -\frac{3^{m}\,58^{s}\cdot44}{24^{h}\,18^{m}\,47^{s}\cdot88} = -3^{m}\,55^{s}\cdot36 \div 24^{h}$$

and rate on mean time $= + 0^{s}\cdot55$.

Rates of the Chronometers from the 19th to the 21st.

For Motel, No. 39.

$$\begin{array}{lll} A_{,} - B_{,} = 7^{h}\,58^{m}\,3^{s}\cdot69 & & A_{,} = 18^{h}\,14^{m}\,15^{s}\cdot18 \\ A - B = 7\;\;50\;\;7\cdot90 & & A = 18\;\;19\;\;41\cdot83 \\ \hline +\;7\;\;55\cdot79 & & -\;5\;\;26\cdot65 \end{array}$$

$$\beta = -\frac{7^{m}\,55^{s}.79}{2 \times 24^{h} - 5^{m}26^{s}\cdot65} = -3^{m}\,58^{s}.43 \div 24^{h}$$

being a rate of $- 2^{s}\cdot52$ on mean time.

For Baker, No. 744.

$$\begin{array}{lll} Z_{,} - C_{,} = 7^{h}\,56^{m}\,48^{s}\cdot40 & & Z_{,} = 17^{h}\,38^{m}\,56^{s}\cdot10 \\ Z - C = 7\;\;49\;\;2\cdot75 & & Z = 18\;\;12\;\;20\cdot32 \\ \hline +\;7\;\;45\cdot65 & & -0\;\;33\;\;24\cdot22 \end{array}$$

$$\beta = -\frac{7^{m}\,45^{s}\cdot65}{2 \times 24^{h} - 0^{h}\,33^{m}\,24^{s}\cdot22} = -3^{m}\,55^{s}\cdot56 \div 24^{h}$$

Being a rate of $+ 0^{s}\cdot35$ on mean time.

Rates of the Chronometers from the 21st to the 22d.

Motel, No. 39.

$$\begin{array}{lll} A_{,} - B_{,} = 8^{h}\;\;2^{m}\;\;0^{s}\cdot14 & & A_{,} = 18^{h}\,11^{m}\,24^{s}\cdot77 \\ A - B = 7\;\;58\;\;3\cdot69 & & A = 18\;\;14\;\;15\cdot18 \\ \hline +0\;\;3\;\;56\cdot45 & & -\;0\;\;2\;\;50\cdot41 \end{array}$$

$$\beta = -\frac{3^{m}\,56^{s}\cdot45}{24^{h} - 2^{m}\,50^{s}\cdot41} = -3^{m}\,56^{s}\cdot92 \div 24^{h}$$

being a rate of $- 1^{s}\cdot01$ on mean time.

Rates of the Chronometers from the 21st to the 22d.

Baker, No. 744.

$$Z_{\prime} - C_{\prime} = 8^{h}\ 0^{m}\ 47^{s}\cdot04 \qquad Z_{\prime} = 17^{h}\ 47^{m}\ 55^{s}\cdot62$$
$$Z - C = 7\ \ 56\ \ 48\cdot40 \qquad Z = 17\ \ 38\ \ 56\cdot10$$
$$+\ 3\ \ 58\cdot64 \qquad +\ 0\ \ 8\ \ 59\cdot52$$

$$\beta = -\frac{3^{m}\ 58^{s}\cdot64}{24^{h}\ 8^{m}\ 59^{s}\cdot52} = -\ 3^{m}\ 57^{s}\cdot16 \div 24^{h}$$

Being a rate of — $1^{s}\cdot25$ on mean time.

The rates originally assigned to the chronometers on leaving Paris and London, were respectively (on mean time),

Motel No. 39, + $1^{s}.8$. Baker 744, + $1^{s}.20$.

The former, then, in the interval must have altered its rate (if that deduced from the observations of the 18th and 19th be correct), no less than — $7^{s}\cdot63$; and between the 18th and 21st, must have again accelerated its daily rate by $3^{s}\cdot31$, fluctuations not to be supposed in a chronometer of any character. It is therefore probable that the rate — $5^{s}\cdot83$ of the 18th-19th is incorrect, and the observations being positive, and liable to no errors capable of accounting for so large a deviation, the cause, on this supposition, can lie nowhere but in some accidental derangement in that interval. Now it unfortunately happens, that the interval B — B′, on the 18th, to which this suspicious rate is to be applied, is no less than $41^{m}\ 20^{s}\cdot6$, which produces a correction of — $0^{s}\cdot17$, or nearly two-tenths of a second in the result of that night's observations.

If we examine the individual observations of both nights, on which this rate depends, we shall find no satisfaction, though they tend to confirm the suspicion of a derangement

in the intervening day, by indicating rather a gain, than a loss on mean time;—but the unavoidable errors of observation will not permit the deduction of a rate from such short intervals as those elapsed during the observations of a single night.

However, we may be relieved from the disagreeable necessity of rejecting the night's observations on this score, by reflecting, that all observations are liable to *some* errors; that if we reject this on account of a suspected error of two tenths of a second, arising from the fault of a chronometer, we certainly should not be warrantable in retaining the result of the observations of the 21st, where the whole night's work rests on a single signal, and on the transit of a single star observed at Greenwich, and where an error to the extent of nearly half a second, from both causes united, may very fairly be presumed. We may be relieved, I say, from the necessity of rejecting observations where there are assuredly none to spare, by remarking that, according to any fair estimation of the weight of each night's result from the number of observations, the most suspicious result, that of the 21st, is precisely that which holds the lowest rank—and that whether we retain or reject those of the two nights in question, the ultimate result will (as will hereafter appear), be unaffected to the extent of more than three-hundredths of a second.

Actual Calculation and Results.

Computation of the observations of the 18th.

1st Combination. All the observers taken jointly.

A	B	B′	C′	C″	Z″
$18^h\,15^m\,40^s{\cdot}37$	$10^h\,29^m\,34^s{\cdot}4$	$9^h\,54^m\,52^s{\cdot}0$	$9^h\,46^m\,29^s{\cdot}75$	$9^h\,41^m\,46^s{\cdot}2$	$17^h\,26^m\,46^s{\cdot}25$
18 35 41·13	10 49 32·8	10 14 54·0	10 6 31·40	9 51 49·6	17 36 51·02
18 45 44·13	10 59 33·6			10 1 50·3	17 46 53·62
				10 11 48·6	17 56 53·31
				10 21 46·9	18 6 53·42
				10 41 47·2	18 26 57·05
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 32 21·88	10 46 13·6	10 4 53·0	9 56 30·57	10 8 28·13	17 53 32·44
A—B =	7 46 8·28	B—B′ =	+ 41 20·60	Gain on M. T. of B—0·17	
B′—C′ =	0 8 22·43	C′—C″ =	— 11 57·56	—— of C—0·00	
	7 54 30·71		+ 29 23·04		
C″—Z″ =	—7 45 4·31	Gain of mean on Sid. Time -	— 4·82		
	0 9 26·40				
	—4·82				
	—0·17				
	0·00				
	0 9 21·41	= Corrected difference of Longitudes.			

Computation of the observations of the 19th.

1st Combination. All the observers taken jointly.

A	B	B′	C′	C″	Z″
$17^h\,29^m\,29^s{\cdot}6$	$9^h\,39^m\,30^s{\cdot}4$	$9^h\,44^m\,49^s{\cdot}4$	$9^h\,36\,33^s{\cdot}10$	$9^h\,42^m\,0^s{\cdot}45$	$17^h\,30^m\,56^s{\cdot}55$
18 39 52·5	10 49 41·1	9 54 49·9	9 46 36·65	9 51 53·65	17 40 51·34
18 49 43·4	10 59 30·4	10 34 49·7	10 26 33·70	10 1 56·50	17 50 55·77
		10 54 53·4	10 46 37·55	10 22 2·45	18 11 5·09
				10 32 24·75	18 21 28·65
				10 41 59·80	18 31 5·58
				10 51 59·60	18 41 7·11
				11 2 3·40	18 51 12·50
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 19 41·83	10 29 33·93	10 17 20·60	10 9 4·49	10 23 17·57	18 12 20·32
A—B =	+7 50 7·90	B—B′ =	+ 12 13·33		
B′—C′ =	+ 8 16·11	C′—C″ =	— 14 13·02	Gain of B on M. T. — 0·02	
				of C —— 0·00	
	+7 58 24·01		— 1 59·69		
C″—Z″ =	—7 49 2·75	Gain of mean on Sid. T. - -	+ 0·33		
	9 21·26				
	+ 0·33				
	— 0·02				
	0·00				
	0 9 21·57	= Corrected difference of Longitudes.			

Calculation of the observations of the 21st.

1st. Combination. All the observers jointly.

A	B	B′	C′	C″	Z″
$17^h\ 37^m\ 23^s·10$	$9^h\ 39^m\ 24^s·70$	$9^h\ 54^m\ 50^s·40$	$9^h\ 46^m\ 38^s·95$	$9^h\ 42^m\ 7^s·7$	$17^h\ 38^m\ 56^s·10$
17 47 32·10	9 49 32·70	10 4 53·10	9 56 41·50		
18 7 40·95	10 9 38·60	10 14 51·20	10 6 39·80		
18 17 30·30	10 19 26·40	10 34 49·60	10 26 38·25		
18 37 40·75	10 39 33·20	10 44 59·40	10 36 47·90		
18 57 43·90	10 59 33·30	11 4 51·80	10 56 41·10		
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 14 15·18	10 16 11·49	10 26 32·58	10 18 21·25	9 42 7·7	17 38 56·10

A — B =	7 58 3·69	B — B′ =	—0 10 21·09	Gain of B on M. T. = + 0·01
B′ — C′ =	8 11·33	C′—C″ =	+0 36 13·55	C . . . — 0·03
	8 6 15·02		+0 25 52·46	
C′—Z″ =	-7 56 48·40	Gain of mean on Sid. Time -	— 4·54	
	9 26·62			
	—4·54			
	+0·01			
	—0·03			
	0 9 22.06	= Corrected difference of Longitudes.		

Calculation of the observations of the 22d.

1st. Combination. All the observers jointly.

A	B	B′	C′	C″	Z″
$17^h\ 31^m\ 12^s·15$	$9^h\ 29^m\ 18^s·6$	$9^h\ 44^m\ 50^s·50$	$9^h\ 36^m\ 39^s·80$	$9^h\ 32^m\ 8^s·95$	$17^h\ 32^m\ 53^s.27$
17 51 18·70	9 49 21·9	9 54 53·50	9 46 42·45	9 42 6·95	17 42 53·36
18 1 15·65	9 59 17·1	10 4 53·20	9 56 42·50	9 52 8·55	17 52 56.56
18 11 21·70	10 9 21·7	10 15 8·60	10 6 57·85	10 2 9·90	18 2 59.28
18 21 43·60	10 19 41·7	10 24 48·30	10 16 37·50		
18 31 31·80	10 29 28·4	10 34 58·70	10 26 48·05		
18 51 29·80	10 49 23·0	10 44 57·60	10 36 47·00		
		10 54 47·70	10 46 37·15		
		11 4 48·80	10 56 37·90		
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 11 24·77	10 9 24·63	10 24 54·10	10 16 43·36	9 47 8·58	17 47 55·62

A—B =	8 2 0·14	B — B′ =	— 15 29·47	Gain of B on M. T. +0·01
B′— C′ =	8 10·74	C′—C″ =	+ 29 34·78	C . . . —0·03
	8 10 10·88		+ 14 5·31	
C″—Z″ =	-8 0 47·04	Gain of Mean on Sid. Time -	— 2·31	
	9 23·84			
	—2·31			
	+0·01			
	—3·03			
	0 9 21·51	= Corrected difference of Longitudes.		

Calculation of the observations of the 18th.

2d Combination. Capt. SABINE. Mr. HERSCHEL.

A	B	B′	C′	C″	Z″
18h 15m 40s·37	10h 29m 34s·4	9h 54m 52s	9h 46m 29s·7	9h 41m 46s·0	17h 26m 46s·25
35 41·13	49 32·8	10 14 54	10 6 31·4	51 49·5	36 51·02
45 44·13	59 33·6			10 1 50·3	46 53·62
				11 48.6	56 53·31
				21 47.0	18 6 53·42
				41 47·2	26 57·05
Mean = 18 32 21·88	Mean = 10 46 13·6	Mean = 10 4 53	Mean = 9 56 30·55	Mean = 10 8 28·1	Mean = 17 53 32·44

A — B = 7 46 8·28   B — B′ = + 41 20·60 Gain on M.T. −0·17

B′ — C′ = 0 8 22·45   C′ — C″ = — 11 57·55 Gain on M.T. −0·01

7 54 30·73   (B — B′) + (C′ — C″) = 29 23·05

C″ — Z″ = −7 45 4·34   Gain of mean on Sid. Time = — 4.82

0 9 26·39
—4·82
—0·17
—0·01

0 9 21·39 = The corrected difference of Longitudes.

Calculation of the observations of the 19th.

2nd Combination. Observations of Capt. SABINE and Mr. HERSCHEL.

A	B	B′	C′	C″	Z″
17h 29m 29s·6	9h 39m 30s·4	9h 54m 50s·0	9h 46m 33s·8	9h 42m 0s·5	17h 30m 56s·55
18 39 52·5	10 49 41·2	10 34 49·6	10 26 33·7	9 51 53·8	17 40 51·34
18 49 43·4	10 59 30·0	10 54 53·6	10 46 37·6	10 1 56·4	17 50 55·77
				10 22 2·5	18 11 5·09
				10 32 24·8	18 21 28·65
				10 41 59·7	18 31 5·58
				10 51 59·8	18 41 7·11
				11 2 3·5	18 51 12·50
Mean. 18 19 41·83	Mean. 10 29 33·87	Mean. 10 28 11·07	Mean. 10 19 55·03	Mean. 10 23 17·63	Mean. 18 12 20·32

A — B = + 7 50 7·96   B — B′ = + 0 1 22·8   Gain of B on M. T. = 0.00

B′ — C′ = + 0 8 16·04   C′ — C″ = — 0 3 22·6   —— C —— 0·00

+ 7 58 24·00   — 0 1 59·8

C″ — Z″ = — 7 49 2·69   Gain of mean on Sid. Time = + 0·33

9 21·31
+ 0·33
+ 0·00
— 0·00

0 9 21·64 Corrected difference of Longitudes.

Calculation of the observations of the 21st.

2d Combination. Observations of Capt. SABINE and Mr. HERSCHEL.

A	B	B′	C′	C″	Z″
17^h 37^m 23^s·10	9^h 39^m 24^s·8	9^h 54^m 50^s·4	9^h 46^m 39^s·0	9^h 42^m 7^s·7	17^h 38^m 56^s·10
17 47 32·10	9 49 32·8	10 4 53·2	9 56 41·5		
17 7 40·95	10 9 38·4	10 14 51·2	10 6 39·8		
18 17 30·30	10 19 26·4	10 34 49·6	10 26 38·3		
18 37 40·75	10 39 33·2	10 44 59·4	10 36 47·9		
18 57 43·90	10 59 33·2	11 4 52·0	10 56 41·1		
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 14 15·18	10 16 11·47	10 26 32·63	10 18 21·27	9 42 7·7	17 38 56·10
A — B =	7 58 3·71	B — B′ =	—0 10 21·16	Gain of B on mean T.	—0·01
B′ — C′ =	8 11·36	C′ — C″ =	+0 36 13·57	of C - -	+0· 3
	8 6 15·07		+0 25 52·41		
C″ — Z″ =	-7 56 48·40	Gain of mean on Sid. T. -	— 4·54		
	9 26·67				
	—4·54				
	—0·01				
	+0·03				
	0 9 22·15	Corrected difference of Longitudes.			

Calculation of the observations of the 22d.

2d Combination. Observations of Capt. SABINE and Mr. HERSCHEL.

A	B	B′	C′	C″	Z″
17^h 31^m 12^s·15	9^h 29^m 18^s 6	9^h 44^m 50^s·8	9^h 36^m 39^s·8	9^h 32^m 9^s·0	17^h 32^m 53^s·27
17 51 18·70	9 49 22·0	9 54 53·6	9 46 42·5	9 42 7·0	17 42 53·36
18 1 15·65	9 59 17·2	10 4 53·2	9 56 42·5	9 52 8·6	17 52 56·56
18 11 21·70	10 9 22·0	10 15 8·8	10 6 58·0	10 2 10·1	18 2 59·28
18 21 43·60	10 19 41·6	10 24 48·4	10 16 37·3		
18 31 31·80	10 29 28·6	10 34 58·8	10 26 48·2		
		10 44 57·6	10 36 47·0		
		10 54 48·0	10 46 36·9		
		11 4 48·8	10 56 38·0		
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 4 43·93	10 2 45·00	10 24 54·22	10 16 43·36	9 47 8·67	17 47 55·62
A — B =	8 1 58·93	B — B′ =	— 22 9·2	Gain of B on M. T.	— 0·03
B′ — C =	0 8 10·86	C′ — C″ =	+ 29 34·7	of C - -	+ 0·03
	8 10 9·79		+ 7 25·5		
C″ — Z″ =	8 0 46·95	Gain on Sid. T.	— 1·22		
	9 22·84				
	— 1·22				
	— 0·03				
	+ 0·03				
	0 9 21·62	= Corrected difference of Longitudes.			

Calculation of the observations of the 18th.

3d Combination. Capt. Sabine (for Col. Bonne)—M. Largeteau.

A	B	B′	C′	C″	Z″
$18^h\,15^m\,40^s$·37	$10^h\,29^m\,34^s$·4	$9^h\,54^m\,52^s$·0	$9^h\,46^m\,29^s$·8	$9^h\,41^m\,46^s$·4	$17^h\,26^m\,46^s$·25
35 41 ·13	49 32 ·8			51 49 ·7	36 51 ·02
45 44 ·13	59 33 ·6			10 21 46 ·8	18 6 53 ·42
				41 47 ·2	26 57 ·05
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 32 21 ·88	10 46 13 ·6	9 54 52 ·0	9 46 29 ·8	10 9 17 ·52	17 54 21 ·93
A—B =	7 46 8 ·28	B — B′ =	0 51 21 ·6	Gain of B on M.T. =	— 0 ·21
B′—C′ =	0 8 22 ·20	C′— C″ =	—0 22 47 ·7	of C - -	— 0 ·02
	7 54 30 ·48		0 28 33 ·9		
C″—Z″ =	—7 45 4 ·41	Gain of mean on Sid. T. - - } =	—4 ·68		
	0 9 26 ·07				
	— 4 ·68				
	— 0 ·21				
	— 0 ·02				
Δ =	0 9 21 ·16	The corrected difference of Longitudes.			

Calculation of the observations of the 19th.

3d Combination. Col. Bonne and M. Largeteau.

A	B	B′	C′	C″	Z″
$18^h\,39^m\,52^s$·5	$10^h\,49^m\,41^s$ 0	$9^h\,44^m\,49^s$·4	$9^h\,36^m\,33^s$·2	$9^h\,42^m\,0^s$·4	$17^h\,30^m\,56^s$·55
18 49 43 ·4	10 59 30 ·8	9 54 49 ·8	9 46 33 ·5	9 51 53 ·5	17 40 51 ·34
		10 34 49 ·8	10 26 33 ·7	10 1 56 ·6	17 50 55 ·77
		10 54 53 ·2	10 46 37 ·5	10 22 2 ·4	18 11 5 ·09
				10 32 24 ·7	18 21 28 ·65
				10 41 59 ·9	18 31 5 ·58
				10 51 59 ·4	18 41 7 ·11
				11 2 3 ·3	18 51 12 ·50
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 44 47 ·95	10 54 35 ·90	10 17 20 ·55	10 9 4 ·47	10 23 17 ·52	18 12 20 ·32
A—B =	7 50 12 ·05	B—B′ = +	0 37 15 ·35	Gain of B on M.T. = +	0 ·04
B′—C′ =	8 16 ·08	C′—C″ = —	0 14 13 ·05	C - -	—0 ·01
	7 58 28 ·13		+ 0 23 2 ·3		
C″—Z″ = —	7 49 2 ·80	Gain of mean on Sid. Time } =	— 3 ·78		
	9 25 ·33				
	—3 ·78				
	+ 0 ·04				
	—0 ·01				
	0 9 21 ·58	Corrected difference of Longitudes.			

Calculation of the observations of the 21st.

3d Combination. Observations of Col. BONNE and M. LARGETEAU.

A	B	B′	C′	C″	Z″
17^h 37^m 23^s·10	9^h 39^m 24^s·6	10^h 34^m 49^s·6	10^h 26^m 38^s·2	9^h 42^m 7^s·7	17^h 38^m 56^s·10
17 47 32·10	9 49 32·6	10 44 59·4	10 36 47·9		
18 7 40·95	10 9 38·8				
18 57 43·90	10 59 33·4				
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 7 35·01	10 9 32·35	10 39 54·50	10 31 43·05	9 42 7·7	17 38 56·10
A — B =	7 58 2·66	B — B′ =	— 30 22·2	Gain of B on mean T.	— 0·04
B′ — C′ =	8 11·45	C′ — C″ =	+ 49 35·3	of C - -	+ 0·04
	8 6 14·11		+ 19 13·1		
C″ — Z″ =	-7 56 48·40	Gain of mean on Sid. T. - -	— 3·15		
	9 25·71				
	—3·15				
	—0·04				
	+0·04				
	0 9 22·57	Corrected difference of Longitudes.			

Calculation of the observations of the 22d.

3d. Combination. Col. BONNE and M. LARGETEAU.

A	B	B′	C′	C″	Z″
17^h 51^m 18^s·70	9^h 49^m 21·8	9^h 44^m 50^s·2	9^h 36^m 39^s·8	9^h 32^m 8^s·9	17^h 32^m 53^s·27
18 1 15·65	9 59 17·0	9 54 53·4	9 46 42·4	9 42 6·9	17 42 53·36
18 11 21·70	10 9 21·4	10 15 8·4	10 6 57·	9 52 8·5	17 52 56·56
18 21 43·60	10 19 41·8	10 24 48·2	10 16 37 7	10 2 9·7	18 2 59·28
18 31 31·80	10 29 28·2	10 34 58·6	10 26 47·9		
18 51 29·80	10 49 23·0	10 54 47·4	10 46 37·4		
		11 4 48·8	10 56 37·8		
Mean.	Mean.	Mean.	Mean.	Mean.	Mean.
18 18 6·88	10 16 5·53	10 24 53·57	10 16 42·96	9 47 8·50	17 47 55·62
A — B =	8 2 1·35	B — B′ =	— 8 48·1	Gain of B on M. T. =	—0·01
B′ — C′ =	8 10·61	C′ — C″ =	+ 29 34·5	of C - -	+0·02
	8 10 11·96		+ 20 46·4		
C″ — Z″ =	-8 0 47·12	Gain of mean on Sid. T. - -	= —3·40		
	9 24·84				
	— 3·40				
	— 0·01				
	+ 0·02				
	0 9 21·45	= Corrected difference of Longitudes.			

In appreciating the weights to be attributed to these several results, it is obvious that the numbers of corresponding observations at each pair of stations, and of transits at the observatories, as it essentially influences the probable accuracy of the mean comparison of their timekeepers must be the elements of all fair estimations. If corresponding observations at any station be wanting, the weight is evidently nothing; so that calling x, y, z, the numbers of corresponding observations at A and B, at B and C, and at C and Z respectively, $x \times y \times z$ must necessarily be a multiplier of the function expressing the joint weight of the whole. But if the number of observations at any one station, or at all, be infinitely multiplied, the weight is clearly not infinite. If at *all* the stations, it would afford only such a degree of evidence as a perfect comparison of the clocks would give, which is but a relative certainty, after all, and may be denoted by unity. In like manner, if the observations at any one pair of stations be infinitely multiplied, the result is still open to all the errors of imperfect observations at the rest, so that unity will in like manner be the maximum of the coefficient depending on any separate set. The function

$$\frac{x}{x+1} \times \frac{y}{y+1} \times \frac{z}{z+1}$$

is the simplest which satisfies these conditions, each factor vanishing when its variable is o, and becoming unity when infinite. The same reasoning applies to the transit observations by which the clocks are compared with the stars, so that calling T and t the number of transit observations taken at each, by which the clock's errors are obtained, the function expressive of the weight of any night's observations will be

$$W = \frac{T}{T+1} \times \frac{x}{x+1} \times \frac{y}{y+1} \times \frac{z}{z+1} \times \frac{t}{t+1}.$$

It would be needless refinement to enquire minutely how far this agrees with a strict calculation of probabilities.

The result of the whole operation may then be briefly stated as follows:

Day of Obs.	Δ	x	y	z	T	t	W	W× (Δ—$9^m\ 21^s$)
18th.	$9^m\ 21^s{\cdot}41$	3	2	6	5	6	$\frac{3}{4}\cdot\frac{2}{3}\cdot\frac{6}{7}\cdot\frac{5}{6}\cdot\frac{6}{7}=0{\cdot}31$	0·1271
19th.	9 21 ·57	3	4	8	3	3	$\frac{3}{4}\cdot\frac{4}{5}\cdot\frac{8}{9}\cdot\frac{3}{4}\cdot\frac{3}{4}=0{\cdot}30$	0·1710
21st.	9 22 ·06	6	6	1	4	1	$\frac{6}{7}\cdot\frac{6}{7}\cdot\frac{1}{2}\cdot\frac{4}{5}\cdot\frac{1}{2}=0{\cdot}15$	0·1590
22d.	9 21 ·51	7	9	4	5	5	$\frac{7}{8}\cdot\frac{9}{10}\cdot\frac{4}{5}\cdot\frac{5}{6}\cdot\frac{5}{6}=0{\cdot}44$	0·2244
							Sum 1·20)	0·6815 (0·568=mean.

Most probable mean of the whole, so obtained - - - = $9^m\,21^s{\cdot}568$

Mean, similarly taken, but rejecting the results of the 18th and 21st as liable to suspicion - - - - - - - - 9 21 ·535

Arithmetical mean of all the four results - - - - - 9 21 ·64

Arithmetical mean of the results of the four nights, obtained by the 2d combination, or from Capt. Sabine's and Mr. Herschel's observations alone - - - - - - - - - 9 21 ·70

Arithmetical mean of the 3d combination, or Col. Bonne's and M. Largeteau's observations taken separately - - - 9 21 ·69

On the whole then, $9^m\ 21^s{\cdot}6$ may be assumed as a result not very likely to be altered a whole tenth of a second, and very unlikely to be altered to twice that extent, by future determinations.

J. F. W. HERSCHEL.

London, November 2, 1825.